

were established on the east side of the north tip to test different vegetation manipulation techniques. In one experimental plot the vegetation was pulled out by hand, and in the other experimental plot the vegetation was weed-whacked and then covered with landscape cloth. Four additional 30×30 meter experimental plots were added between the fall of 2001 and the spring of 2002 and subjected to (1) herbicide application and raking, (2) herbicide application and burning, (3) raking only, and (4) burning only. Through both seasons of testing, productivity of terns and predator activity within the plots was closely monitored with the results from vegetation manipulation. Experimental vegetation manipulation during 2001 to 2002 showed that of the six treatments used, burning and a combination of herbicide and burning produced a habitat type that most deterred nesting laughing gulls and enticed nesting common terns (USFWS 2007b). Although the combination of herbicide and raking produced the most significant alterations in vegetation structure, burning alone was the only type of management that actually resulted in a decline in the number of nesting laughing gulls that persisted for 2 years.

Since the vegetation work in 2001 to 2002, three controlled burns have been conducted on the refuge to improve nesting habitat for terns. On April 8, 2004, two 60×60 meter plots were burned on the southwestern edge of the colony. This area was one of the main areas of encroachment by laughing gulls. Baseline vegetation data was collected prior to the prescribed burn and changes in vegetation cover (dead and alive), open sand, and the amount of duff were measured after the burn, and after the nesting season that immediately followed the burn. Overall, the burn was successful in reducing the number of laughing gulls nesting in these plots while increasing the number of terns. Despite the success of the burn in 2004, however, nesting laughing gulls were again reaching high numbers and another burn was conducted on October 15, 2009. Refuge staff and Region 5 fire personnel burned the entire tern nesting area (36 acres on the north tip of South Monomoy). Refuge staff collected pre-burn vegetation data and post-burn vegetation data to compare percentages of woody species, green vegetation and thatch, and areas of open sand impacted by the burn. Vegetation data collection was continued annually after the burn in 2009 was completed, and it was determined in fall of 2011 that vegetation levels were reaching that of the pre-burn data, indicating the need to burn again. A burn was conducted in October 2012 over the majority of the northern tip of South Monomoy, excluding a small roseate tern nesting area where habitat was already desirable. Post-burn vegetation data has not yet been collected.

Prescribed fire has been used as a tool to thin out areas of vegetation that are considered too thick for tern nesting, and artificial nesting structures have been used to provide additional cover in areas that are too sparsely vegetated for terns. Several areas within the main tern nesting area on South Monomoy are completely void of vegetation. Beginning in 1997, approximately 100 tern boxes (Series 500, modeled after J. Spendelow, USGS/BRD, Patuxent Wildlife Research Center, Laurel, MD) have been placed throughout the colony in areas with little vegetation on South Monomoy. Although this type of box was designed specifically to attract nesting adult roseate terns and provide shelter for large mobile roseate tern chicks (USFWS 1999b), common tern chicks frequently use these boxes for shelter from predators and exposure to inclement weather on South Monomoy.

Large seabird colonies are often a breeding ground for avian disease. Since the documentation of salmonellosis outbreaks beginning in 2004, and the 2005 paralytic shellfish poisoning mortality on South Monomoy, disease monitoring has become a vital component of our biological monitoring program. The tern colony is monitored regularly for adult tern mortality and fledglings

demonstrating symptoms of salmonellosis. The salmonella bacterium is often naturally present at low levels in seabirds and outbreaks commonly manifest in large colonies of nesting terns and gulls. Symptoms of salmonellosis include ruffled feathers, diarrhea, and severe lethargy. Shortly before death, birds may appear unsteady, may shiver, and breathe more rapidly than normal (USGS 1999). Spasms, paralysis, and discolored excretions around the vent are additional signs of salmonellosis. The salmonella bacteria can cause large-scale losses of colonial nesting birds, and once symptoms become readily apparent, death usually occurs within 12 hours. The source of the 2004 salmonellosis infection at Monomoy NWR has not been identified despite efforts to determine its origin.

The colony is also monitored for large mortality events and unusual behavior that could be associated with highly pathogenic avian influenza (HPAI H5N1). The HPAI H5N1 virus has not yet been detected in the United States in either wild migratory waterfowl or domestic birds (USFWS 2006c). Mortality surveys were conducted from 2008 to 2010 in areas with concentrations of sensitive species (terns, gulls, and shorebirds), looking for groups of sick and dead birds. As part of a regional monitoring effort, refuge staff collected cloacal and pharyngeal swabs from 50 live adult common terns during the nesting season from 2008 to 2010. All samples collected and submitted to the National Wildlife Health Center in Madison, WI, tested negative for HPAI.

Least Terns

Least terns generally show high colony site tenacity (Burger 1984) and site fidelity (Atwood and Massey 1988), though their use of Monomoy NWR has varied widely from year to year. Large areas of least tern habitat are available on the refuge, though predator presence is a problem and may be the reason least terns have only nested in small numbers in most years. In 1970, there were three least tern colonies totaling 200 pairs on Monomoy Refuge. Two least tern colonies produced young in 1979, and between 1980 and 1983, least terns were occasionally seen at the beginning of the breeding season. Unsuccessful least tern nest attempts occurred in 1984 and 1985, and the highest count (300 pairs) was recorded in 1987 (USFWS 1988). Monitoring least tern nest attempts may have been inconsistent in past years, but during the last 16 years, all suitable least tern nesting sites have been carefully surveyed during peak nesting times. Survey numbers are included in table 2.9. Most of the nesting least terns on the refuge have been utilizing South Monomoy (south tip, southwest, southeast, and northeast sides), but several pairs have attempted to nest on Minimoy Island when habitat was available. Obtaining accurate productivity estimates is difficult and can cause additional disturbance to nesting birds, but in most years, productivity has been qualitatively defined as poor. Predators (primarily gulls and coyotes) and overwash are often to blame for loss of eggs and chicks.

Table 2.9. Least Terns Nesting on Monomoy NWR (1996 to 2012).*

Year	South Monomoy	Minimoy Island**	Refugewide
1996	103	N/A	103
1997	6 (138)	N/A	6 (138)
1998	246	N/A	246
1999	103	N/A	103
2000	119	N/A	119
2001	16	N/A	16
2002	6 (50)	N/A	6 (50)
2003	62 (143)	0 (6)	62 (149)
2004	1 (229)	0 (1)	1 (230)

Year	South Monomoy	Minimoy Island**	Refugewide
2005	93 (39)	0	93 (39)
2006	57	0	57
2007	32 (51)	0 (7)	32 (58)
2008	144 (6)	0 (5)	144 (11)
2009	5 (7)	3	8 (7)
2010	39 (11)	0	39 (11)
2011	104***	0	104***
2012	52 (152)	0	52 (152)

*The first number listed represents the A-period total and the number in parentheses represents the B-period total nest count.

**Minimoy was not monitored until 2003.

***A ground nest count was not completed during the census window in 2011; only an adult count was done during the window. All other counts in this table are based on peak nest counts completed during the census window June 5 to 20.

Staging Terns

Monomoy NWR hosts thousands of staging terns during the post-breeding season. Common and roseate terns are found in the highest numbers; there are smaller numbers of black terns, Forster's terns, arctic terns, and least terns. Occasionally sandwich and royal terns have been sighted on the refuge.

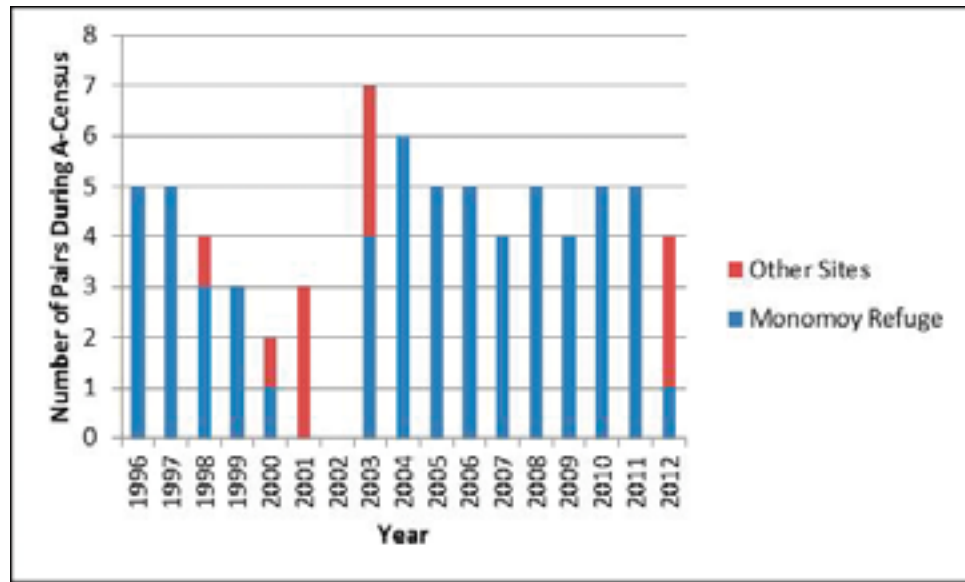
In late July, roseate terns begin moving to staging areas on Cape Cod, including areas of Monomoy NWR. Anecdotal evidence suggests that potentially 100 percent of the roseate tern population uses Cape Cod for a portion of the post-breeding period. The concentration of these birds implies that this period of their life cycle is largely important to their survival. Of the 13.24 km² identified as important during the post-breeding period, 6.18 km² occur on Federal land (Cape Cod National Seashore and Monomoy National Wildlife Refuge) (Jedrey 2010 personal communication).

Beginning in 1998, staging tern counts were conducted opportunistically by refuge staff and generally limited to the flats on the north tip of South Monomoy. A high staging count of 10,890 terns was recorded on August 4, 1999. Beginning in 2007, staff from the Coastal Waterbird Program and USGS conducted staging counts on many different sites throughout Cape Cod, including the refuge, as part of their roseate tern monitoring program, resulting in much more consistent and intense coverage at the refuge. Results from their study have not been finalized. In 2010, refuge staff also began expanding the geographic area of the counts to include the connection of Nauset/South Beach and South Monomoy and areas further north on Nauset/South Beach.

Black Skimmers

Monomoy NWR lies on the northern edge of the black skimmer's breeding range. Over the last three decades, single pairs sporadically nested on the refuge, generally in association with common terns. The nesting population of black skimmers at the refuge climbed to three pairs in 1986 and then declined to zero pairs in the 1990s until 1996 and 1997, when five pairs were recorded (figure 2.8). Since that time, a few black skimmers have continued to nest on the refuge in most years; in many years the refuge has been the only nesting site in Massachusetts. Productivity for these nesting birds has been sporadic with some good years and poor years.

Figure 2.8. Black Skimmers Nesting at Monomoy NWR Compared to Other Sites in Massachusetts (1996 to 2012).



Gulls

Laughing Gulls

Laughing gulls, perhaps displaced from Muskeget Island, first colonized Monomoy NWR in 1971 and succeeded in establishing a colony adjacent to and within the tern colony at the northernmost tip of the refuge. Laughing gull numbers rose steadily during the 1970s to a peak of 1,000 pairs in 1981 (USFWS 1988), but then declined steadily; laughing gulls eventually stopped nesting by the mid-1990s (USFWS 1996b), which was most likely the result of continued expansion of the herring and great black-backed gull populations that encroached on tern and laughing gull nesting areas (USFWS 1996b, USFWS unpublished reports 1985 to 1994). Both laughing gulls and terns benefited from the lethal removal of herring and great black-backed gulls that began in 1996, and by 2002 the population of nesting laughing gulls had increased to 1,106 pairs (USFWS 2003a) and the numbers of pairs continued to increase through 2007 (figure 2.9; USFWS 2009e).

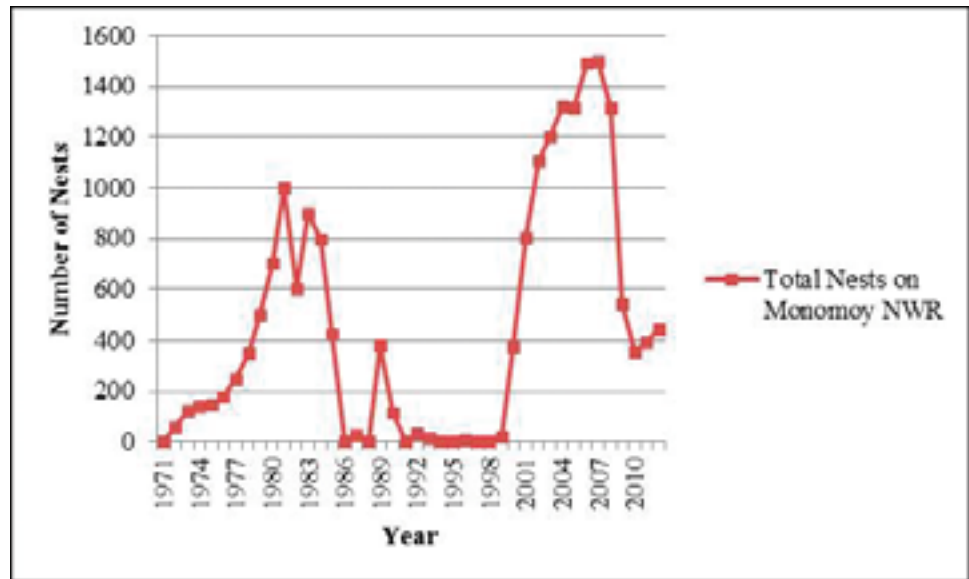
As the laughing gull population increased, their rapid population growth put them in direct competition with roseate and common terns. Each year laughing gulls are counted in conjunction with the annual tern census. See figure 2.9 for trends of nesting laughing gulls on Monomoy NWR.

Black crowned night heron



Gary M. Stolz/USFWS

Figure 2.9. Number of Nesting Laughing Gulls Counted on South Monomoy (A-Census). (The counts for 1972 to 1984 are estimates).



Habitat manipulation and nest destruction are tools that have been used to keep the laughing gull population low and decrease their competition with nesting terns. Refer to appendix J for more information on management techniques used to control the laughing gull population.

Great Black-backed and Herring Gulls

Although it has been reported that several herring gulls nested on Monomoy Island in 1924 (Forbush 1925), the recent history of herring gull nesting on Monomoy NWR started with five pairs in 1963 (Kadlec and Drury 1968). The colony growth in successive years was spectacular with 75 pairs in 1964; 420 pairs in 1965; 1,000 pairs in 1966; 8,000 pairs in 1969; and more than 15,000 pairs in 1980; but in 1995, only 5,200 pairs of herring gulls were found on the refuge. This drop in herring gull numbers may be correlated to the closing of landfills and poor census methods used during the census in 1995. Great black-backed gulls moved onto Monomoy soon after the herring gulls did; there were 75 to 80 pairs in 1965 and 1966 and about 175 pairs in 1972. By 1980, the great black-backed population had reached 3,300 pairs, and in 1995 had reached a total of 7,350 pairs, for a combined count of more than 13,000 pairs of the two large gull species (USFWS 1996b).

These counts (through the mid-1990s) are estimates, however, and uncertainty and inconsistency in methodology over years reduces their reliability. In recent years, complete counts of nesting gulls have been conducted on North Monomoy Island in 2000 and 2007 (refer to table 2.10). In 2000, South Monomoy was surveyed using aerial photography; in 2007, it was surveyed using a stratified random-sample transect method. In 2000, 1,018 great black-backed gulls and 1,609 herring gull nests were counted on North Monomoy Island, but the aerial photography for South Monomoy was never fully analyzed. In 2007, 1,245 herring gull nests and 683 great black-backed gull nests were counted on North Monomoy Island. An additional 1,088 herring gull nests and 2,490 great black-backed gull nests were estimated on South Monomoy, for a total refugewide count of 2,333 herring gull nests and 3,173 great black-backed gull nests.

Table 2.10. Great Black-backed Gull and Herring Gull Nests Counted in Areas A and B During May Gull Censuses in 1996 to 2007* on South Monomoy.

Year	Great Black-backed Gull		Herring Gull		Empty		Total		
	Area A	Area B	Area A	Area B	Area A	Area B	Area A	Area B	Total
1996	307	652	544	178	859	322	1710	1152	2862
1997	78	356	26	51	262	147	366	554	920
1998	7	259	0	10	6	99	13	368	381
1999	2	195	0	35	1	98	3	328	331
2000	0	139	0	33	0	86	0	258	258
2001	3	115	0	28	3	55	6	198*	204*
2002	3	114	0	56	0	47	3	217	220
2003	1	79	0	32	0	47	1	158	159
2004	4	59	0	14	0	104	4	177	181
2005	0	39	0	18	0	61	0	118	118
2006	0	12	0	3	0	43	0	58	58
2007	0	13	0	5	0	17	0	35	35

*No gull census took place in 2008 through 2012.

Gull Control Efforts (1979 to 2008)

During the 1970s, tern populations on Monomoy NWR became restricted in area and declined in numbers, while nesting herring and great black-backed gull populations increased to very high levels and expanded to occupy extensive areas of the refuge, including former tern colony locations (USFWS 1988). Various efforts between 1979 and 1995 were unsuccessful at controlling the gull population on the refuge. In accordance with tasks outlined in the Piping Plover Recovery Plan, Roseate Tern Recovery Plan, Endangered Species Act of 1973, and the goals of the National Wildlife Refuge System in 1996, which direct national wildlife refuge units to “preserve, restore, and enhance in their natural ecosystem (when practicable) all species of animals and plants that are endangered or threatened with becoming endangered,” the Service proposed to strengthen ongoing efforts to manage habitat for nesting species on Monomoy NWR. The Avian Diversity Project began in 1996, and a contiguous 169.5-acre area (67.7 ha) was chosen on the north end of South Monomoy (designated Areas A and B) to provide gull-free nesting habitat. The Service has used a variety of techniques to control nesting gulls and maintain habitat for terns. Details of these efforts are described in appendix J.

Other Colonial Nesting Waterbirds

Monomoy is one of a few remaining nesting sites in the State of Massachusetts for colonial nesting wading birds. The number of nesting black-crowned night-herons on Monomoy NWR increased from 12 pairs in 1980 to 200 pairs in 1987, and this colony size has maintained over the years. Black-crowned night-herons nested each year on South Monomoy until recently, when they began transitioning to nesting sites on North Monomoy Island (figure 2.10). All wading birds nested on North Monomoy Island in 2008 through 2011, with the exception of one black-crowned night-heron nest on South Monomoy in 2009. Black-crowned night-herons nest primarily in rugosa rose, but also utilize bayberry, poison ivy bushes, and beach plum (especially on North Monomoy Island). Dissections performed at the refuge and papers from other heronries in New England

confirm that black-crowned night-herons at Monomoy feed primarily on sand lance, mummichog, assorted other small fish, Fowler toads, meadow voles, immature gulls, and tern eggs and chicks (USFWS unpublished data, Hall and Kress 2008).

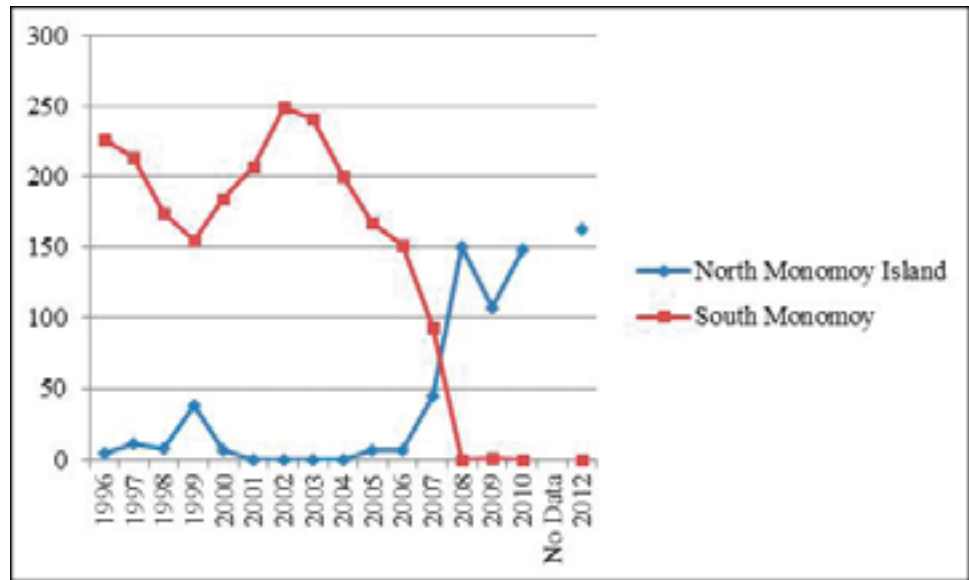


Figure 2.10. Nesting Black-crowned Night-herons on Monomoy NWR (1996 to 2012).

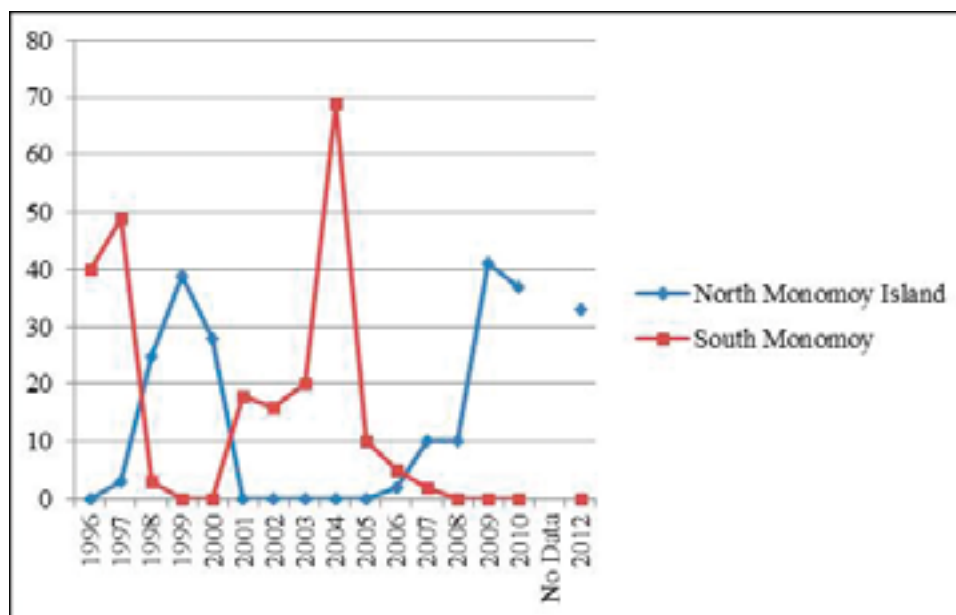
Black-crowned night-herons have been significant predators of tern eggs in past years. Black-crowned night-herons are deemed predatory only when disturbed terns are heard and then observed mobbing a heron walking through the colony in search of nests, or when herons are observed inside the tern colony actively eating tern eggs. Black-crowned night-herons observed flying over the colony or walking near the tern colony and not disturbing terns are not considered predatory and are not removed (Megyesi 1997). Refer to appendix J for more information about control of black-crowned night-herons on the refuge.

Monomoy's snowy egrets first became established on the refuge in 1981 and nest in association with black-crowned night-herons. Feeding habitat within a 5-mile radius of the snowy egret rookery provides ample food, primarily sand lance, mummichogs, and striped killifish (USFWS unpublished data). The nesting population peaked in 1987 with 90 pairs (USFWS 1988) and has fluctuated over the years. The refuge has averaged about 40 pairs in years when snowy egrets were present. In recent years, snowy egrets nested primarily on North Monomoy. In 2009, there were 41 nesting pairs of snowy egrets on North Monomoy Island (USFWS 2012) and in 2010, 37 nesting pairs (USFWS unpublished data), although numbers may be higher than recorded (figure 2.11).

Glossy ibis were recorded nesting in past years on the refuge. In 1999 one pair of glossy ibis nested on North Monomoy Island (USFWS 2000), and in both 2002 and 2004 one pair of glossy ibis nested on South Monomoy Island (USFWS 2003a, 2007b). There have been no glossy ibis nests documented on the refuge since 2004.

Great egrets also periodically nested on the refuge, with nests documented in 1996, 1997, 2005, 2008, 2010, and 2012.

Figure 2.11. Snowy Egrets on Monomoy NWR (1996 to 2012).



Raptors

Short-eared owls and great horned owls are seen on the refuge during the spring and summer months. Bald eagles and peregrine falcons are observed at Monomoy NWR during spring and fall migration and in winter. Other raptors seen on or around Monomoy NWR during migration include sharp-shinned hawks and Cooper's hawks, both State species of special concern. American kestrels, merlin, red-tailed hawks, northern harriers, and snowy owls are seen occasionally on the refuge during the winter months. Data from hawk watch surveys conducted on Morris Island by volunteer Don Manchester from 2001 to 2010 are summarized in table 2.11.

Table 2.11. Hawk Watch Total Hours Observed and Species Counted by Year.

Species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
American kestrel	10	8	6	10	8	0	10	5	1	6
Bald eagle	1	1	0	0	0	1	0	0	0	0
Broad-winged hawk	1	0	1	0	0	5	0	0	0	1
Cooper's hawk	124	123	95	118	129	119	153	137	93	56
Merlin	36	34	43	45	30	0	28	45	21	24
Northern goshawk	2	0	0	7	3	1	4	2	1	1
Northern harrier	9	42	29	23	16	18	18	14	11	6
Osprey	8	11	13	24	10	26	24	19	27	31
Peregrine falcon	104	39	44	113	83	90	67	95	82	36
Rough-legged hawk	0	1	0	0	0	0	0	0	0	0
Red-shouldered hawk	2	0	0	0	1	0	3	1	2	2
Red-tailed hawk	2	e	7	45	42	90	59	49	48	32
Sharp-shinned hawk	1062	754	406	692	549	1442	802	939	575	291

Species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Turkey vulture	12	19	21	30	29	26	30	53	30	29
Unidentified Accipiter	25	11	12	10	3	5	10	6	5	5
Unidentified Buteo	0	0	0	0	0	0	1	0	0	0
Unidentified Falcon	2	0	1	1	0	1	0	0	0	0
Unidentified Raptor	4	4	3	4	1	7	1	2	4	1
Total Hours Surveyed	207	214.5	248	254	136	249	214.5	213.5	145	112

Historically, short-eared owls, a State endangered species, nested on Monomoy NWR; however, no nesting has been recorded in recent years. In 1984, four pairs nested in the refuge, five pairs nested in 1985 and 1986, and two pairs nested in 1987 (USFWS 1988).

Great horned owls have nested in recent years on Monomoy NWR, but no official counts have been conducted (Iaquinto 2011 personal communication). Great horned owls have been active predators on the refuge in past years. Evidence of owl predation, including sightings of owls and pellets collected from the tern colony, has been documented in most years since 2004. For more information on predator management techniques refer to appendix J.

Northern harriers, a State threatened species, also nest on the refuge. Four northern harrier nests were found in the refuge in 1997, three nests in 1998, at least one nest in 1999, and three nests in 2000. The islands were not searched in their entirety during these and in subsequent years, and these numbers are likely an underestimate. In recent years, staff has been limited and the island has not been searched for nesting owls or harriers, though northern harriers are seen frequently on all portions of the refuge. Northern harriers are not controlled on the island or discouraged from hunting in the common tern colony.

Other Birds of Conservation Concern

Breeding songbird surveys were conducted on South Monomoy from 1996 to 2006. Earlier surveys (1996 to 2001) were conducted using a transect protocol and were limited to the northern half of South Monomoy. In 2001, we switched to using a protocol that was developed by the USFWS and was standardized for all refuges in Region 5 to allow comparisons across refuges. This protocol consisted of 32 fixed points on South Monomoy that were surveyed annually from 2001 to 2006. During the 6 years, 62 species and 2,620 individual birds were recorded; however, many were flyovers of non-songbirds. Of the breeding songbirds, the most commonly recorded were red-winged blackbirds (379 recorded), common yellowthroat (292 recorded), song sparrow (290 recorded), savannah sparrow (247 recorded), and common grackle (116 recorded). Other songbirds recorded on surveys include tree swallow, horned lark, barn swallow, eastern kingbird, yellow warbler, gray catbird, salt marsh sparrow, American goldfinch, willow flycatcher, brown-headed cowbird, bank swallow, and cliff swallow (USFWS unpublished data). Refer to appendix A for a complete list of documented breeding songbirds on the refuge.

Point counts to detect salt marsh sparrows and other salt marsh species have been conducted on the refuge to collect baseline data for these habitats. Salt marsh sparrows breed actively in salt marsh habitats on the refuge. Though no surveys have been done to measure productivity, it has been confirmed that this species has bred on the refuge in each year surveys were conducted. Counts were conducted at one point on Morris Island three times annually between 2001 and 2005 and at six points on North Monomoy Island two to three times

annually between 2005 and 2010 (no surveys were conducted in 2008). At least 5 years of survey data was collected for each point. In 2011 through 2013, as part of the Salt marsh Habitat and Avian Research Project (SHARP), point counts were conducted by seasonal staff associated with the University of Maine under the supervision of PhD student Maureen Correll. These surveys conducted by the SHARP project will be used to investigate changes in tidal marsh bird populations on the refuge and in eastern Massachusetts over the past 20 years by comparing current data collection to over 20 years of historical data. In addition to point counts, rapid assessment vegetation surveys were completed as part of the study following protocols of the USGS Salt marsh Integrity Project.

Two separate special use permits have been issued for additional research pertaining to salt marsh sparrows on the refuge in recent years. In 2011, Oksana Lane from the BioDiversity Research Institute (BRI) in Maine, collected blood samples from salt marsh sparrows on North Monomoy Island. Objectives of the research were to measure mercury exposure in adult and hatch year salt marsh sparrows by sampling blood and feathers. BRI took blood samples from 22 individuals and found that only four of these individuals had slightly elevated mercury levels (above $0.7 \mu\text{g/g}$) (unpublished data, 2011 Special Use Permit #53514-11016 Annual Report) but were below the estimated reproductive success effect level of $1.2 \mu\text{g/g}$ in songbird blood (Jackson et al. 2011).

In 2013, as part of the SHARP project, PhD student Jen Walsh, from the University of New Hampshire, collected blood samples from salt marsh sparrows on North Monomoy Island with an objective of confirming that the refuge was outside the zone of hybridization with Nelson's sparrows. The results of this work have not yet been reported to the refuge.

In 2011, volunteer James Junda founded the Monomoy Refuge Banding Station (MRBS) with cooperation of the refuge staff. It was operated in 2011 and 2012 by both volunteers and highly trained professional banders. Operations were based upon the protocols of other constant-effort banding stations in the United States and Canada, with an emphasis on standardized research protocols (Junda 2013). Fall migration monitoring provides the basis for long-term trend analysis of migrating birds using the refuge. The protocol used on the refuge is designed to be comparable with the methodology of other fall migration banding stations. The protocol includes regular monitoring, standardized census, banding, and incidental observations taken each day staff was present at the station. The fall migration season extends from August 15 to November 15. In 2011, the banding station was open on 14 days; during 2012, the effort was increased to a total of 36 days, though coverage was intermittent due to weather unsuitable for banding. A total of 934 birds and one bat comprising 73 different species were captured and banded in 2011; during 2012, 1,787 individual birds of 79 species were captured. In total, 91 species have been banded at the MRBS between the 2011 and 2012 fall migration seasons. In addition to daily banding performed at the MRBS, banders attempted to trap saw-whet owls three nights in early November using playback calls. Ultimately they captured and banded two owls. A separate banding effort was also conducted by MRBS staff to sample salt marsh sparrows on North Monomoy Island. In total, 18 salt marsh sparrows were mist netted and banded during two days of netting.



USFWS

Northern gannet

The most commonly captured birds in the 2 years were myrtle warblers, tree swallows, red-breasted nuthatch, and savannah sparrows. The top 10 most common species captured over the 2 years can be seen in table 2.12. A number of species rare to the refuge were captured, including bay-breasted warbler, black-throated grey warbler, blue grosbeak, bobolink, clay-colored sparrow, lark sparrow, pine siskin, rusty blackbird, Townsend's solitaire, white-winged crossbill, and yellow-throated warbler.

Discussion about the possibility of erecting a wind turbine to provide power to the Monomoy Point light keeper's house prompted preconstruction surveys during 2010 and 2011 to determine bird use of the area during migration and the nesting season. Surveys were performed from mid-August through October in 2010 and from mid-April through September in 2011. While these surveys were designed to evaluate potential impact to birds resulting from a wind turbine (variables such as height of flight were recorded), they provide useful baseline data about frequency and abundance of bird use in this area.

Table 2.12. Most Common Species Captured at MRBS 2011 to 2012 (includes recaptures).

Species	2011	2012
Myrtle warbler	274	360
Tree swallow	157	286
Red-breasted nuthatch	0	162
Savannah sparrow	63	83
Golden-crowned kinglet	17	72
Slate-colored junco	12	75
Song sparrow	26	51
Pine siskin	0	49
Common yellowthroat	26	47
Palm warbler	12	46

Data are still being analyzed, but a preliminary summary is presented here. In 2010, staff recorded 1,107 observations comprising 3,938 birds within the proposed wind turbine survey area. Of the 2,582 identifiable birds, 53 species were recorded. The 2011 surveys resulted in 1,816 observations of 13,067 birds. From the 11,825 birds identified, 64 species were recorded. The most common species observed in the survey area in 2010 included tree swallow (1,790), house sparrow (136), yellow-rumped warbler (60), double-crested cormorant (59), and bank swallow (56). The most common species observed in 2011 included tree swallow (9,779), red-winged blackbird (285), common tern (273), common grackle (257), and double-crested cormorant (198).

Mammals

Marine Mammals

Gray seal, a Massachusetts species of special concern, and harbor seal are found on the refuge and in the surrounding waters. Gray seals use the refuge for hauling out and pupping. In fact, Monomoy NWR is the largest haulout site for gray seals on the U.S. Atlantic seaboard, and one of only two consistent sites in Massachusetts where gray seals pup. Gray seals use the refuge lands and waters all year. Gray seal pupping is limited but may be increasing, though there have never been high levels of pupping on the refuge. Many more gray seals pup on Muskeget, an island off of Nantucket. Gray seals start to group up in late autumn and pupping generally occurs from mid-December to early February. Pups are nursed for three weeks until they molt their white coat. Once the pups molt, they disperse and may be seen at distances relatively far from where they were born. Males will breed with females immediately following pupping.

Official counts of gray seal adults have not been conducted since the late nineties, so an exact population estimate is not known. Since the population is always changing and is relatively plastic, it is difficult to narrow down how many individuals use the refuge lands and waters, but it is certainly in the thousands.

In 1999, Margaret E. Barlas completed a study on the distribution and abundance of gray and harbor seals that included aerial surveys. In her study, the high count for gray seals on Monomoy was a May 1999 count of 3,322 individuals. No harbor seals were counted at that time, but the number has certainly increased in recent years.

Harbor seals are winter, not year-round, residents on the refuge. They generally start arriving in refuge waters in early September and remain until late March. Numbers of these seals increase slowly through this time period and then quickly drop off in March. Though harbor seals are still present, their numbers are not as high as in the past. Gray seals seem to be displacing harbor seals to some extent, but the two species will haul out together, with gray seals occupying the upper beach and harbor seals staying closer to the water. Peak pupping for harbor seals is in June and occurs elsewhere, mainly on the coasts of Maine and maritime Canada (Waring 2010 personal communication).

Terrestrial Mammals

Monomoy NWR's small terrestrial mammals, which include the masked shrew, northern short-tailed shrew, white-footed mouse, common muskrat, meadow jumping mouse, and meadow vole, serve as prey for the refuge's raptors. Of these, the meadow vole is the most abundant small mammal. Although none are known residents, the big brown bat, red bat, and hoary bat have also been recorded on Monomoy Refuge (USFWS 1988). In 2010 and 2011, ultrasonic recordings were made to survey bats flying over the area surrounding the Monomoy Point Lighthouse, but data are still being analyzed. No other formal terrestrial mammal surveys have been conducted on the refuge since 1988.

When the island first became isolated from the mainland, the Service removed red fox. Mammal sightings were rare through the 1980s (long-tailed weasel (1983), Norway rats (1985), raccoon (1986)). Since 1995, mammals including red fox, raccoon, striped skunk, and Virginia opossum have been periodically noted on the refuge. In 2000, one striped skunk was seen; in 2001, a striped skunk was shot and removed from the refuge; and in 2011 skunk tracks were seen near the lighthouse. In 2007 a raccoon carcass was found near the lighthouse, and raccoon tracks were seen several times in 2010 through 2012. Tracks and a raccoon carcass were observed on Nauset/South Beach near the South Monomoy connection in 2012. No live raccoon were seen on the islands or South Monomoy since 2005. Virginia opossum were seen or confirmed as present most years between 2006 and 2012, though they were only a problem for nesting birds in 2008. River otter were sighted in the fresh water ponds in 2007, 2011, and 2012. For more information on small mammal predation on the refuge refer to appendix J.

Evidence of coyote on Monomoy NWR was first recorded in 1996 (USFWS 1997), and evidence of coyote denning has been observed in most years since 1998. Beginning in 1998, lethal coyote removal has been conducted to minimize depredation on nesting birds. The refuge has employed a variety of techniques that are outlined in appendix J.

It is possible that the presence of potential mammalian predators (i.e., coyote, red fox, domestic dog, fisher, mink, weasel, striped skunk, river otter, raccoon, opossum, and muskrat) will increase. Access to the island became easier for land based mammalian predators with the connection to Nauset/South Beach in November 2006, and an increase was seen in mammal activity on South Monomoy. It appears that the February 2013 break in Nauset/South Beach could be contributing to a decline in the number of coyotes seen in the spring and summer of 2013 on the refuge.

Between 1960 and 1980, the white-tailed deer population on Monomoy remained fairly constant at 15 to 25 individuals. A high count of 30 deer was made in 1984, but during March and April of 1985, 11 winter and storm-killed deer were found; necropsies revealed the deer had been in poor health. An aerial survey conducted in January 1986 tallied 15 deer on the refuge, and the deer population has likely remained around 15 to 25 since that time (USFWS 1988), although no formal deer surveys have been conducted since 1986. More recent information on deer using South Monomoy is anecdotal and has come in large part from staff spending the summer working near the lighthouse.

Amphibians and Reptiles

No formal studies have been conducted to inventory amphibians or reptiles on Monomoy NWR; however, Fowler's toad, American toad, eastern ribbon snake, and common garter snake are present on the refuge. Eastern hognose snakes have been confirmed on the refuge, though they are rare and have not been documented every year.

Sea Turtles

Five sea turtle species--green, hawksbill (rare visitor), Kemp's ridley, leatherback, and loggerhead--can be found in the waters surrounding the refuge and are all protected under the U.S. Endangered Species Act (see appendix A for species status). The National Marine Fisheries Service (NOAA-NMFS) is the lead agency for pelagic sea turtle recovery. The Massachusetts Audubon Society's Wellfleet Bay Sanctuary operates and maintains a sea turtle sighting hotline for southern New England boaters (<http://www.seaturtlesightings.org>; accessed July 2013). The sighting hotline site provides maps of sightings by turtle species, year, and month. The hotline maps and data points do not represent a systematic survey, nor an accurate count of sea turtles, but are helpful for characterizing sea turtle status and use near Monomoy.

The nearshore open waters of northeastern Nantucket Sound, including those west of Monomoy, are a primary June through September feeding location for adult leatherbacks turtles, the most commonly sighted species (<http://seaturtlesightings.org/monthmap.html>; accessed July 2013, Prescott 2013 personal communication) when jellyfish become abundant. July and August are the peak months for sea turtle sightings around Monomoy. Loggerhead turtles were also sighted almost annually since 2003, and Kemp's ridley turtles are sighted somewhat less often in the Nantucket Sound waters west of Monomoy. As water temperatures warm in the spring, sea turtles migrate north from tropical and subtropical waters to inhabit their northern foraging grounds. Juveniles and, to a lesser extent, adults are found along the New England coast from May through November, when water temperatures are favorable, and return south before the onset of winter (NOAA 2013).

Threats to sea turtles in the marine environment include bycatch in commercial and recreational fisheries, vessel collisions, and marine debris entanglement and ingestion (NOAA 2013). Several species have been recovered or entangled in refuge waters in recent years. Since 1996, there have been nine documented sea turtle entanglements (six leatherbacks and three loggerheads) with fixed fishing gear (pots and wiers) on or near the refuge (map 2.5) (Landry 2013 personal communication). In 2008, a dead Kemp's ridley sea turtle was recovered within the refuge Declaration of Taking boundary. When dead or stranded sea turtles are discovered on the refuge they are reported to Mass Audubon, who manages immediate response for stranded sea turtles on Cape Cod, and to the NOAA Fisheries Service Northeast marine mammal and sea turtle stranding hotline. Given the potential that seasonal use of refuge waters within the Declaration of Taking boundary may be increasing, gear entanglement and vessel strike



incidence for sea turtles may correspondingly increase during the 15-year plan period to a point where additional management actions may be required.

Fish

Aquatic species on Monomoy NWR are found in both freshwater and saltwater ponds and marshes. Freshwater ponds and marshes on South Monomoy cover more than 140 acres (USFWS 1988). There are no freshwater ponds or marshes on North Monomoy, Minimoy, or Morris Islands. The main freshwater ponds on South Monomoy are Big and Little Station Ponds; other small freshwater ponds and wetlands dot the island. The two main salt ponds on South Monomoy are Hospital Pond and Powder Hole. Almost 25 acres of salt marsh surround the 5-acre estuarine Hospital Pond at the northern end of South Monomoy. Powder Hole, which in the mid-1800s was a deep and extensive harbor, is now a shallow estuarine waterbody on the southwest end of the refuge.

Freshwater Fish

Big Station Pond, approximately 32 acres, and Little Station Pond, approximately 11 acres, naturally formed on South Monomoy as deep saltwater lagoons, which subsequently became cut off from the ocean and are now freshwater ponds. Big Station Pond may occasionally get an influx of salt water from high storms (Iaquinto 2011 personal communication). Both are considered warm water ponds. Very little formal information about the fisheries and ponds on Monomoy is available; however, it is likely the ponds on the refuge have American eel, as well as mosquitofish and other small fish (Camisa 2011 personal communication). In 1951 and 1952, the Service stocked largemouth bass in these ponds and bass were abundant for a few years.

Saltwater Fish

A large number of fish species are found in Nantucket Sound and the Atlantic side of South Monomoy. These fish species are listed in appendix A, as compiled from the State of Massachusetts Division of Marine Fisheries (MDMF) trawl surveys. The rich diversity of marine life is a result of the unique geographic location of Nantucket Sound. It is located along the confluence of the cold Labrador Current and the warmer Gulf Stream, creating an ecological transitional zone where the ranges of southern and northern species overlap (Center for Coastal Studies 2003).

The sand eel or American sand lance, a small fish abundant in the ocean waters around Monomoy, is an important food species for many larger fish and for colonial waterbirds nesting on the refuge (USFWS 1988). Striped bass and bluefish are commonly found in the nearshore waters in Nantucket Sound off South Monomoy.

The Magnuson-Stevenson Fishery Conservation Act (MSFCMA) of 1976 established eight regional councils tasked with managing various fishery resources within Federal waters. The New England Fishery Management Council (NEFMC) and the Mid-Atlantic Fishery Management Council (MAFMC) are responsible for developing fishery management plans for species inhabiting Nantucket Sound. The Sustainable Fisheries Act (1996) amendment to MSFCMA requires NOAA National Marine Fisheries Service and the management councils to identify and describe essential fish habitat (EFH) for federally managed species, and specify actions to conserve and enhance EFH. Congress defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity” (16 U.S.C. § 1802(10)). Additionally, management councils designate habitat of particular concern (HAPC) to areas within EFH that are ecologically important, sensitive to disturbances, or rare (50 CFR 600.815(8)). Designating HAPC is intended to specify high priority areas within EFH where managers should focus conservation efforts.

Essential fish habitat designations occur in portions of open water within the Declaration of Taking boundary for 13 federally managed species of fish, including Atlantic cod, pollock, windowpane flounder, winter flounder, yellowtail flounder, white hake, silver hake, little skate, winter skate, ocean pout, Atlantic wolffish, smooth dogfish, and Atlantic bluefin tuna (table 2.13; NOAA 2009b, NEFMC 2012). Waters in the Declaration of Taking boundary have also been identified as habitat of particular concern for juvenile Atlantic cod (NEFMC 2012).

Table 2.13. Essential Fish Habitat at Monomoy NWR.

Common Name	Scientific Name	Life History Stages			
		Egg	Larval	Juvenile	Adult
Major Gadids					
Atlantic cod	<i>Gadus morhua</i>	X	X	X	
Pollock	<i>Pollachius virens</i>			X	
Flat Fish					
Windowpane flounder	<i>Scophthalmus aquosus</i>			X	X
Winter flounder	<i>Pseudopleuronectes americanus</i>		X		X
Yellowtail flounder	<i>Limanda ferruginea</i>			X	X
Hakes					
White hake	<i>Urophycis tenuis</i>		X	X	
Silver hake	<i>Merluccius bilinearis</i>	X	X	X	
Skates					
Little skate	<i>Raja erinacea</i>			X	X
Winter skate	<i>Leucoraja ocellata</i>			X	
Other Species					
Ocean pout	<i>Zoarces americanus</i>	X			X
Atlantic wolffish	<i>Anarhichas lupus</i>	X	X	X	X
Highly Migratory Species					
Atlantic bluefin tuna	<i>Thunnus thynnus</i>			X	X
Smooth dogfish	<i>Mustelus canis</i>	X	X	X	X

Source: Data assembled from the New England Fishery Management Council Essential Fish Habitat and Habitat Area of Particular Concern Designation Alternatives Draft 2012; and NOAA Fisheries Division of Highly Migratory Species Amendment 1 to the consolidated Highly Migratory Species Fishery Management Plan, June 2009.

Invertebrates

Countless species of marine invertebrates, including insects, shellfish, horseshoe crabs, and marine worms, amphipods, and other crustaceans inhabit the refuge's terrestrial and intertidal habitats. Many of these are a vital food source for shorebirds and seabirds (USFWS 1988). Although no formal, standardized surveys have been done to document abundance and diversity of invertebrate species, Leavitt and Peters (2005) compiled a table of benthic species that are likely to occur on the sandflats of Monomoy NWR. As stated in Leavitt and Peters (2005), the list, "was generated based on reported presence of the organisms in local sandflats coupled with further investigation into their life history details, primarily using Weiss (1995)." The table of likely species can be found in appendix A.

In 2007, refuge staff collected sediment core samples to quantify invertebrate species available for foraging shorebirds. A 10-cm diameter corer was used to a depth of 5 cm (sample volume of 393 cm³), with samples collected during two sampling periods (July 7 to July 22 and August 23 to September 8), which coincided with peak migration periods of the most abundant shorebird species on the refuge (Koch and Paton 2009). A total of 375 samples was collected during each sampling period. All macrofauna (greater than 1 mm) were counted and classified into six categories: (1) amethyst gem clams; (2) mollusks (Phylum Mollusca, except *G. gemma*); (3) annelids (Phylum Annelida); (4) horseshoe crab eggs, membranes, or larvae; (5) arachnids/insects (Classes Arachnida and Insecta); and (6) crustaceans (Class Crustacea). A mean estimate of abundance/core of each macrofauna category was calculated for each sampling period and is in table 2.14 below. The mean abundance for each category was statistically different between time periods (Koch 2010).

Table 2.14. Macrofauna Abundance in Sediment Cores.

Prey category	(SE) core ¹	
	Period 1	Period 2
Gemma gemma	118.1 (5.50)	164.1 (10.18)
Phylum Mollusca	17.1 (1.33)	40.3 (2.82)
Phylum Annelida	2.7 (0.28)	3.9 (0.40)
Horseshoe crab eggs	0.9 (0.15)	0.4 (0.08)
Classes Arachnida and Insecta	0.5 (0.11)	0.7 (0.19)
Class Crustacea	3.4 (0.26)	4.9 (0.48)

Intertidal marine flats and nearshore marine waters are an important source of softshell clams, northern quahogs, blue mussels, bay scallops, sea scallops, and surf clams. Shorebirds and gulls feed on shellfish in intertidal flats and mussel beds in Nantucket Sound, while sea ducks utilize subtidal shellfish.

Horseshoe Crab

The intertidal habitat at Monomoy NWR hosts one of the largest spawning sites for horseshoe crabs in Massachusetts (USFWS 2002). Horseshoe crabs are an important component of the Northeast coastal ecosystem and their eggs are an integral part of the coastal food web. Horseshoe crab eggs provide an important food source for birds, including gulls (Botton and Loveland 1993, Shuster Jr. 1982, Penn and Brockman 1994, Burger and Wagner 1995 as cited in Burger 1996) and migrating shorebirds. In addition, horseshoe crab eggs and larvae are often eaten by minnows and juveniles of larger fish, (Harrington and Shuster Jr. 1999, Mugford 1975, USFWS 1988, Finley 2011 personal communication) including killifish species (Finley 2011 personal communication), such as striped killifish, eel species such as American eel, (Warwell 1897, deSylva et al. 1962), weakfish, northern kingfish, Atlantic silverside, summer flounder, winter flounder (deSylva et al 1962, Penn and Brockman 1994), striped bass (Martin 1974), and white perch (Shuster Jr. 1982). Other fauna observed feeding on horseshoe crab eggs, hatchlings, and adults include sand shrimp (Price 1962), eight mollusk species (Perry 1940, as in Shuster Jr. 1982), fiddler crabs, Shuster Jr. 1958 as in Shuster Jr. 1982), blue crab, green crab, spider crab in Barnstable Harbor, MA (Shuster Jr. 1958 as in Shuster Jr. 1982), devil ray, (Teale 1945 as cited in Shuster Jr. 1982), puffers (Shuster Jr. 1958 as cited in Shuster Jr. 1982), sharks, and loggerhead sea turtles (Atlantic States Marine Fisheries Commission [ASMFC] 1998b and 1999a).

There is no known recreational fishery for the horseshoe crab, but they are commercially harvested for use as bait for American eel and conch or whelk fisheries. Horseshoe crab blood is also important to biomedical research and pharmaceutical testing (refer to chapter 3 for more details). Concern over the growing exploitation of horseshoe crabs has been expressed by State and Federal fishery resource agencies, conservation organizations, and fishery interests. Harvest closures in states south of Massachusetts in the early 2000s motivated harvesters to move their operations north. The increased harvesting pressure on Monomoy NWR caused refuge staff to review the position on horseshoe crab harvesting. At that time, one biomedical harvester was issued a special use permit by the refuge to collect horseshoe crabs from refuge water by special use permit. Commercial harvesting for bait was never officially permitted, and beginning in 2000, refuge staff enforced a prohibition on all harvesting activity and denied further special use permits for biomedical harvesting. A local horseshoe crab harvester filed a lawsuit against the USFWS and the neighboring National Park Service as a result. The USFWS completed a comprehensive compatibility determination released to the public on May 22, 2002, and resurveyed the refuge boundary. The final decision to prohibit all horseshoe crab harvesting on the refuge is still enforced today.

Refuge staff conduct spawning counts in some years to provide a long-term index of the local population size; they also tag and re-sight tagged horseshoe crabs to learn more about local movement patterns and contribute to rangewide studies of harvest activities. Conducting spawning counts in concert with other sites in Massachusetts is important because of the role the refuge plays in overall recovery. The refuge also serves as a control site when evaluating the impacts of harvest at other sites on population, sex ratios, and mean size. Spawning surveys were first conducted on the refuge in 2000, when the ban on harvesting began. Between 2000 and 2002 a study was conducted that compared spawning and sex ratios on four sites on Cape Cod including Monomoy Refuge. Monomoy NWR and Nauset Estuary consistently had the lowest sex-ratios of the four sites (Monomoy NWR 1:1.9, Nauset Estuary 1:1.6). In 2000, Monomoy NWR had significantly lower ratios (more females to males) than either Pleasant Bay or Cape Cod Bay. There was both a lower frequency of females and a higher frequency of males at the non-refuge sites (James-Pirri 2012). Spawning indices at Monomoy were 1 to 1.9 in the original survey period between 2000 and 2002, and were 1 to 1.8 between 2008 and 2009 (James-Pirri et al. 2005).

Tagging has been conducted in cooperation with the Maryland Fisheries Resource Office every year since 2001 (see table 2.15 for total number of crabs tagged). Data are used to track changes in populations over time, document movement between embayments, and document impacts of harvest activity.

Table 2.15. Total Number of Horseshoe Crabs Tagged on Monomoy NWR (2001 to 2012).

Year	Number of Males	Number of Females	Total crabs Tagged	Total Number of Resights Reported*
2001	510	328	838	19
2002	398	150	548	43
2003	332	104	436	14
2004	291	118	409	20
2005	288	303	593	19
2006	266	134	400	14

Year	Number of Males	Number of Females	Total crabs Tagged	Total Number of Resights Reported*
2007	299	147	446	19
2008	394	48	442	13
2009	347	139	486	28
2010	377	85	462	34
2011	438	156	598	54
2012	612	191	803	55

**The number of re-sights includes crabs from one cohort that have been re-sighted in multiple years.*

Since tagging began in 2001, 332 crabs have been re-sighted and reported. Between 2001 and 2007, tags were reported to a hotline at the refuge office, but reports were often incomplete. In 2008, the refuge began using disc tags issued by the Maryland Fisheries Resource Office, which included a tag re-sight phone number at that office. With Monomoy NWR's formally joining this project, resightings can be much more efficiently collected by volunteers at one location and, therefore, information on resightings since 2008 is likely more complete (Iaquinto 2013 personal comment). Approximately half of the crabs reported as being alive when resighted since 2008 (73 in total) were reported by beachcombers. Crabs are also reported by a variety of other observers, including refuge or Nauset/South Beach staff, sport or commercial fishermen, and biomedical companies. Though harvest is not allowed on the refuge, some crabs are likely captured for bait or bleeding outside the refuge boundary, and reported. Most of the 73 crabs reported alive were released, though 5 were kept for bait, 3 were bought or sold, and 1 was reported as "other." One hundred four of the crabs resighted were reported as being found dead; the majority of these were reported by beachcombers. Only seven crabs were reported with an unknown status (USFWS unpublished data). Seventy-six percent of the crabs resighted since 2008 were found in the Chatham area. Forty-four crabs were found in different towns, though the majority of them were on Cape Cod, the islands of Martha's Vineyard and Nantucket, or immediately adjacent towns surrounding Buzzard's Bay. One crab was found in Fenwick, DE, and must have been transported by artificial means.

Insects

Portions of South Monomoy were surveyed as part of the Virginia Tech piping plover study mentioned in the Federally Listed Endangered or Threatened Species section of this document. Researchers collected invertebrates on South Monomoy. The invertebrates found in largest numbers were flies (Order Diptera), beetles (Order Coleoptera), and crustaceans (Order Crustacea) (Keane 2002).

Informal surveys of dragonflies (Order Odonata) were completed on several trips to South Monomoy by Blair Nikula, Jackie Sones, and Jeremiah Trimble in the 1990s. The species present during these surveys have been listed in appendix A, though it is likely that additional species occur on the refuge as occasional visitors from the mainland or vagrants from farther afield. (Nikula 2013 personal communication).

Hairy-necked tiger beetle, bronzed tiger beetle, and margined tiger beetle, also commonly listed as salt marsh tiger beetle, are also present on the refuge, along with one species of robber-fly (family Asilidae) (Kapitulik 2011 personal communication).

Invasive Species

No formal inventory has been done of invasive species on the refuge, although *Phragmites* and *rugosa* rose are known to exist on Monomoy NWR. *Rugosa* rose is used by herons, egrets, and gulls as nesting habitat and has not been controlled on the refuge. *Phragmites* occurs in both shallow, freshwater marshes and intertidal habitats (Gucker 2008). This species is a persistent and hearty perennial plant that can reach heights up to 20 feet tall and out-compete native plant species (Gucker 2008). *Phragmites* often forms single-species stands with thick mats of roots and rhizomes.

In July 2003, refuge staff collected *Phragmites* samples from 12 different stands (map 2.6) on South Monomoy and submitted them to Cornell University to determine if they are the native or introduced genotypes. All samples (included the two stands discussed below) were diagnosed by Dr. Bernd Blossey as the introduced genotypes.

In 2011, efforts were made to control the spread of *Phragmites* in the main tern colony on South Monomoy. A small stand occurs in a low-lying, centrally located area within the South Monomoy common tern colony. This particular stand provides protection and cover for predators such as coyotes. A second stand occurs south of the primary nesting area, providing an additional space to conceal predators. *Phragmites* control work was not continued in 2012 due to time constraints and poor weather during the months of September and October.

Mute swans are an exotic species of waterfowl introduced from Europe sometime in the late 1800s. This species of swan is very aggressive during nesting season and has been documented killing the young of other nesting waterfowl nearby. In 1996, 12 adult mute swans were observed in the refuge, although no formal surveys were conducted. Mute swans are lethally removed by refuge staff in order to prevent the establishment of a mute swan population on the refuge.

Refuge Visitor Services Program

The Improvement Act designated six priority public uses on national wildlife refuges: hunting, fishing, wildlife observation, photography, environmental education, and interpretation. As detailed in the Service's "General Guidelines for Wildlife-Dependent Recreation," (605 FW 1), we will strive to meet the criteria for a quality wildlife-dependent recreation program.

All of the six priority public uses are currently occurring on the refuge, although the refuge has never officially been open for waterfowl hunting. Based on staff observations and refuge-led programming, opportunities for the remaining five priority uses are being provided in varying degrees, and are in demand by visitors and residents of Chatham and the surrounding area. All of these activities are sufficiently provided elsewhere on Cape Cod, including on adjacent Town of Chatham land and the Cape Cod National Seashore. As such, refuge land restrictions do not eliminate the opportunity for those public uses elsewhere in the Chatham area.

In recent years, the Service has recognized the importance of connecting children with nature. Scholars and health care professionals are suggesting a link between a disconnection with the natural world and some physical and mental maladies in our Nation's youth (Louv 2005). We strive to promote the concept of connecting children and families with nature in all of our compatible wildlife-dependent recreational opportunities. We look to our partners such as the Friends of Monomoy, Mass Audubon, the National Park Service, the Town of Chatham, and others to help us develop and assist with both formal environmental education and informal programming to utilize the outdoors as a classroom.

When developing plans for recreational uses, the refuge staff first evaluates the potential for negative impacts to wildlife, and completes a compatibility



determination to ensure that the use does not materially interfere with purposes of the refuge or the mission of the Refuge System. The refuge seeks locations and creates designs that would provide high quality wildlife experiences for visitors, while also taking into account the ability to maintain programs and facilities over time with existing resources and funding. Refuge efforts are increased by assistance from our Friends group, volunteers, and other partners, without whose help we would be unable to develop or deliver current and proposed recreational programs.

The U.S. Geological Survey, in collaboration with the USFWS, conducted visitor surveys for selected refuges nationwide; Monomoy NWR was among those chosen. During the summers of 2010 and 2011, with help from volunteers, the refuge requested contact information from visitors. The USGS used this information to contact and interview participants. The information collected was presented in a report, National Wildlife Refuge Visitor Survey Results: 2010/2011 (Sexton et al. 2011), made available to the public. The individual results for Monomoy NWR provide a summary of trip characteristics and experiences of a sample of visitors. These data can be used to inform decision-making efforts related to the refuge, such as visitor services management, transportation planning and management, and during the planning of this draft CCP/EIS. This effort will allow for a better understanding of visitors' recreational, educational, and informational experiences, and will measure satisfaction with current services, access, and facilities.

In the survey results report, we learned that 70 percent of visitors were aware of the role of the U.S. Fish and Wildlife Service in managing national wildlife refuges, and 84 percent aware that the Refuge System has the mission of conserving, managing, and restoring fish, wildlife, plants, and their habitat. While most visitors are not aware of the day-to-day refuge operations that occur, they realize the refuge plays an important role in conservation. Of those who responded, approximately 75 percent travelled beyond 50 miles to visit the refuge; within that 75 percent of travelers, 50 percent of them stated that visiting the refuge was one of many equally important reasons for their trip.

The visitor characteristics showed that nearly all (93 percent) surveyed visitors to Monomoy NWR indicated that they were citizens or permanent residents of the United States. Only those visitors 18 years or older were sampled. Visitors were a mix of 53 percent male with an average age of 59 years and 47 percent female with an average age of 54 years. Visitors, on average, reported they had 17 years of formal education (graduate or professional school). The median level of income was \$75,000 to \$99,000. Visitors to the refuge were predominantly Caucasian (96 percent).

Based on visitation estimates, approximately 68 percent of visitors are participating in wildlife-dependent recreational uses. In the USGS survey, 94 percent of respondents stated they were satisfied with the recreational activities and opportunities available. Although each visitor may have individual reasons to visit the refuge and stay for varying lengths of time, it became clear through conducting this survey that those visiting are individual families (as opposed to large groups), with 84 percent of visitors using private vehicles to access Morris Island. This statistic points to the parking congestion we have been facing at the refuge for many years, which has resulted in decreased access to potential visitors as they cannot locate an available authorized parking spot. Respondents stated they were likely to use a boat that goes to different points on refuge waterways; an offsite parking lot that provides trail access; a bus/tram that provides a guided tour; and a bike share program. We intend to address these access needs in the implementation of the transportation study through the strategies identified in chapter 3 (available online at: <http://www.fws.gov/northeast/monomoy/>).

Some uses, such as sport fishing or birdwatching, require wildlife and are considered priority public uses. By law, we are to facilitate all priority public uses that are compatible on the refuge. Others, such as swimming, sunbathing, or dog walking, do not require wildlife. These latter uses are not priority public uses and do not need to be offered by the refuge. In this section, we describe the priority, non-priority, and unauthorized uses that have been occurring on the refuge in recent years.

People come to the refuge for a variety of reasons. Table 2.16 describes refuge visitation in 2012.

Table 2.16. Number of Visitors by Activity in 2012.

Activity	Visitors
Visitor center	14,500
Other non-priority public uses	12,000
Wildlife observation	5,000
Special events	3,600
Fishing	1,650
Nature photography	500
Interpretive programs onsite	75
Environmental education programs onsite	25
Total	37,350

Priority Wildlife-Dependent Public Uses

Described below are the current opportunities the refuge provides for engaging in priority public uses as defined by the National Wildlife Refuge System Improvement Act of 1997. Portions of the refuge are closed seasonally to protect wildlife, as shown in maps 2.7 and 2.8. Visitors may drive, walk, or bicycle to the visitor contact station, beach, and trails on Morris Island. Parking is somewhat limited at this site. North Monomoy Island and South Monomoy are accessible by boat or, in season, by commercial ferry, which offers opportunities for wildlife viewing and fishing. The refuge is open from ½-hour before sunrise to ½-hour after sunset, except for surf fishing on Morris Island, which is allowed 24 hours a day.

Wildlife Observation and Photography

A ¾-mile trail, the Morris Island Trail located on Morris Island, winds through a variety of coastal habitats and offers a unique opportunity to access two viewing locations. Overlooks along the trail provide views of the refuge's North Monomoy Island and South Monomoy. There is a small trail on North Monomoy Island; there are no formal trails on South Monomoy. Historically, a boat was needed to access both North Monomoy Island and South Monomoy, but with the connection of South Monomoy to Nauset/South Beach in 2006, visitors could walk 5 miles to the refuge from Chatham's Lighthouse Beach. The February 2013 breach made this impossible. Visitors reach the islands by private boats or, in season, by commercial ferries that operate on the refuge under a special use permit. These remote locations provide superior landscape and seasonal wildlife viewing opportunities in a nationally designated wilderness area.

Fishing

The Monomoy NWR offers superb recreational fin fishing opportunities late spring through fall, as well as softshell clam harvesting. Anglers are allowed to surf fish in any of the areas open to public access, as well as 24-hour fishing on





Morris Island. Striped bass, bluefish, bonito, and false albacore are among some of the species commonly fished from shore or boat. All State regulations apply, and anglers are required to have a State saltwater fishing license. Recreational shellfishing areas are more restrictive and visitors must possess a Town of Chatham shellfishing permit. The only shellfishing to date that has been found compatible and is, therefore, authorized on the refuge is softshell clam harvesting using traditional hand tools. We know that other types of shellfish, lobster, conch, and whelk harvesting has occurred in refuge waters, but the refuge has never officially been opened to these uses.

Commercial fishing guides facilitate recreational fishing on the refuge. Captains are required by the Massachusetts Division of Marine Fisheries to obtain a for-hire fishing permit to operate in State waters. We know that commercial guides work on the refuge, but special use permits have not been issued to any guides on the refuge. Because commercial fishing guides have, for the most part, not interacted with refuge staff, we have little information about the number of guides that are operating on the refuge, the number of recreational anglers that are being commercially guided, or where and when they fish.

Hunting

Monomoy NWR has never been officially opened to waterfowl hunting, although we know that there is a long history of waterfowl hunting in the open waters off Monomoy Island. The Monomoy Brantling Club of Boston was established near Shooter's Island and Inward Point in 1862 as steam powered the industrial revolution and leisure time increased (Roscoe 1995, Phillips 1932). Warren Hapgood of Boston, one-time president of the Massachusetts Fish and Game Association, was an original founding member sportsman, along with Chatham locals including George Bearse, Alonzo Nye, David Nye, and Washington Bearse, who assumed the roles of member-guides and caretakers. The club was established near the Common Flats where the Bearse and Nye families found success earning part of their annual livelihoods market gunning for shorebirds and waterfowl during the pre-Civil War decades. Several of the original buildings remained standing at the site until salvaged by the Service in 1953 (figure 2.12; USFWS 1953 unpublished) as their destruction by the encroaching sea became imminent.



Figure 2.12. Monomoy Brantling Club of Boston buildings, storm-battered just prior to demolition in 1953, built near Shooter's Island and Inward Point after the club was established in 1862 (USFWS 1953 unpublished).

Atlantic brant was the principle game sought by club members in sink boxes (Deane 1885) each spring from 1863 to 1909, when spring brant hunting was abolished (Bent 1925, Phillips 1932). Fall sport hunting continued, but was generally less successful than spring hunting due to differing seasonal migration patterns (Bent 1925, Phillips 1932). The log of brant hunting effort and harvest kept by club members (Phillips 1932, Roscoe 1995) and popular articles of the day (Deane 1885) give some insight into the conditions and methods of that era.

The club log (Phillips 1932) records 12,091 brant harvested during spring hunts spanning 2,127 days (about six brant per day) from 1863 to 1909 (figure 2.13). Peak harvests such as the 1867 all-time high of 715, occurred at 3-year to 5-year intervals, apparently coinciding with good nesting success; more than half the brant harvested were juveniles. Conversely, poor harvest years such as the 1895 all-time low of 29 brant, also occurred at 3-year to 5-year intervals, and generally coincided with years of poor juvenile recruitment when young birds were less than 15 percent of the total harvest. Weather and climatic conditions were noted most often as affecting club hunting success during the early years. By 1875, notations in the log indicate user conflicts were beginning on the Common Flats with small boats (especially scallopers), fish weirs, other hunters, and shipwreck/salvage; these continue through the remainder of the record. In 1885 to 1888, geomorphology changes to the protective Nauset Beach were noted as altering brant flight patterns and adversely affecting hunting success.

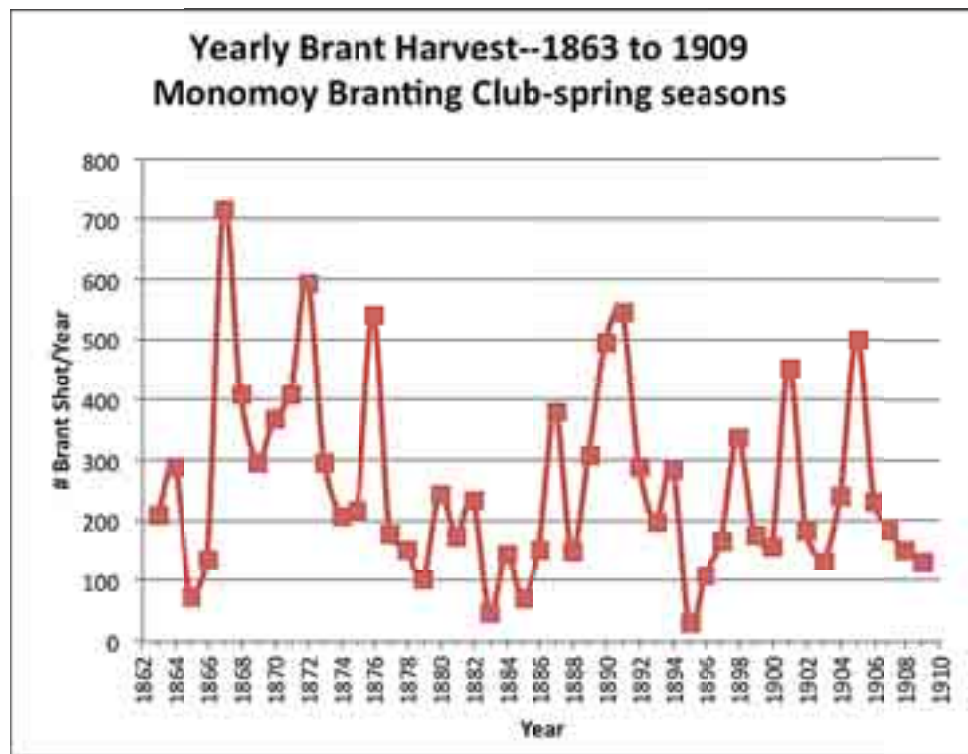


Figure 2.13. Monomoy Branting Club's Annual Brant Harvest.

Sport hunting for waterfowl on and around Monomoy continued increasing in popularity through the late 1800s, spawning rival clubs and entrepreneurs catering to growing numbers of sportsmen such as the Monomoy Shooting Club, of which William "Billy" Bloomer became the proprietor in 1898, assisted by Josiah Hunt (Roscoe 1995). But as concerns over continental waterfowl and shorebird population declines grew into the early 1890s, so did opposition to sport

hunting (Bent 1925), including opposition to the 1923 efforts by the Monomoy Branting Club to gain title to Shooter's Island (Roscoe 1995). Indications of a major decline in the previously abundant eelgrass the brant depended upon for food had become evident by 1931 to 1932 (Phillips 1932), as Monomoy began to come under consideration for establishing a new migratory bird refuge.

Today, waterfowl hunting occurs in the Chatham area and commercial guides market waterfowl hunts around Monomoy, but none have requested a refuge permit to operate within the refuge. It is likely these commercial guides are not aware the refuge has never been opened for waterfowl or any other form of hunting. The actual numbers of commercial guides operating within the refuge, the number of waterfowl hunters that are being commercially guided, where or when they hunt, or what they harvest is unknown.

Interpretation

The refuge headquarters and visitor contact station are located on Morris Island and contain wildlife-themed exhibits and informative brochures. There is also a "Junior Ranger" children's discovery area inside the contact station where young visitors can learn through hands-on activities about the refuge's resources. These activities include scavenger hunts and a "Let's Go Outside" backpack that visitors can take out onto the refuge. The refuge has one official trail at this time, called the Morris Island trail, which is $\frac{3}{4}$ mile long. The Morris Island Trail has interpretive panels that assist in informing visitors about the refuge's purposes and resources. There are additional trails available for walking that extend beyond the Morris Island Trail. Refuge staff, volunteers, and interns offer guided walks and programming throughout the summer months.

Visitors who utilize ferry services also have the opportunity to learn about the refuge while en route to the ferry drop-off sites on North Monomoy Island and South Monomoy. Two ferry services have been issued special use permits to bring anglers and birders to the refuge. One of these also brings seal watchers to the refuge. However, there are other charter boats bringing seal watchers to the waters around the refuge. These operators do not have a permit from the Service to conduct their business on the refuge, and we have been made aware of incidents of seal harassment from some of these boat operators. Refuge staff have no information on the numbers of passengers that come to the refuge for seal watching, nor do we have any information available about the number of charter boats that are operating on and near the refuge.

Environmental Education

Currently, the refuge does not develop and implement formal environmental educational programming. Occasionally, refuge staff conduct educational programming upon request to local schools, colleges, and universities, and we may work with partners to provide environmental education on the refuge. Any areas open to the public are suitable for organized environmental education to occur.

Other Refuge Public Use Activities—Current or Potential

In general, for a public activity to be allowed on a national wildlife refuge, it must first be found appropriate and compatible, in compliance with Service policies (see chapter 1). Activities that were found compatible for Monomoy NWR in 1994 are: beachcombing, hiking/backpacking, jogging/walking, birding, natural and cultural history tours, photography, picnicking, commercial ferry service, snowshoeing, research, sunbathing/swimming, and wildlife observation. We reviewed the 1994 findings during this CCP planning process. Some of our findings have changed. All of our findings are documented in appendix D.

The following lists and describes other public use activities that occur or are likely to occur within the intertidal zone of the refuge and in the adjacent subtidal, benthic zones, and water column, which can impact refuge management and wildlife using the refuge. We previously have not managed some of these

uses, but look at all of them in this document to determine the benefits or impacts of these uses. Activities that occur within the submerged waters within the Declaration of Taking are also described below.

Kite boarding: This is a new use that has been observed adjacent to the refuge and within the Declaration of Taking boundary. Individuals use a large kite to help them move through shallow water areas rapidly. Although it occurs on the surface of the water, it disturbs nesting and staging birds on refuge islands and surrounding flats. This sport is popular around Hardings Beach and Stage Harbor Beach (<http://voices.yahoo.com/cape-cod-kiteboarding-windsurfing-hardings-beach-2189909.html>; accessed April 2013). Kite boarding appears to be replacing “windsurfing” or “sailboarding” in popularity as recreational equipment technology has evolved over the past few decades.

Personal watercraft: Personal watercraft, such as wave runners and jet skis, are not allowed within the Cape Cod National Seashore boundary, within Pleasant Bay, or within the Southway Channel. However, wave runners are allowed within Nantucket Sound and frequently are within the Declaration of Taking refuge boundary on the west side.

Kayaking and Paddleboards: Kayakers and, to a lesser extent, stand-up paddleboarders are often observed using the waters in and around the refuge or pulled up on refuge shorelines during the warmer months. Most of these day trips originate from and return to mainland sites, especially the Morris Island Road causeway that affords vehicle parking and carry-in access to both Outermost Harbor and Stage Harbor; these are a relatively short and sheltered paddle to North Monomoy Island, Nauset/South Beach, and the connection to South Monomoy. Signs indicating that the carry-in/out of kayaks or canoes from refuge parking on Morris Island is prohibited are posted near the stairways providing beach access.

Shellfish Harvesting: The Massachusetts Division of Marine Fisheries established 17 designated shellfish growing areas in the Town of Chatham, MA, which encompass 101,763 acres. Three are located in or adjacent to Monomoy NWR, with Monomoy Island (SC47) being the largest designated area at 37,831 acres. Nearly 80 percent of the harvestable intertidal shellfish flats in the Town of Chatham are located in SC47. Not all of these intertidal flats are within the refuge’s Declaration of Taking. Shellfish harvesting is permitted with town and State permits. The State permit requires shellfishermen to file an annual harvest report with the State and to identify the specific areas harvested. This does not tell us, however, how much of the harvest occurred on the refuge.

Clamming: For over 150 years, the Monomoy area has been known as one of the most productive clamming areas in Massachusetts. Traditionally harvested species are softshell clams, quahogs (hard-shelled clams), and surf clams. Softshell clam harvesting became a lucrative fishery after the 1978 break and subsequent shifting of sands and creation of sandflats. In the past, shellfishing has been concentrated on the point of Morris Island, the Common Flats, and the Powder Hole area. The majority of shellfish harvesting in recent years on the refuge has occurred in intertidal habitat (and in very shallow subtidal areas adjacent to intertidal habitat), primarily on the western side of North Monomoy Island (especially the southern end) and South Monomoy (especially the northern end), the eastern side of Monomoy Island, the area between Morris Island and North Monomoy Island, the area between North Monomoy Island and South Monomoy, and the area between the refuge and Nauset/South Beach (the Southway). Many of the intertidal shellfish harvest areas listed above lie within the Monomoy wilderness boundary. Refer to map 2.9 for locations. Softshell clam harvest using pumps takes place in several designated locations within Chatham, and occurred occasionally within Powder Hole on South Monomoy as recently as 2011, after which the town’s shellfishing regulations were formally amended

on February 21, 2012, by Board of Selectmen action following a public hearing on the rule change to exclude the practice in Powder Hole (Town of Chatham, Board of Selectmen Meeting Minutes for February 21, 2012 available online at: <http://www.mytowngovernment.org/02633>; accessed May 2013). The principal reason for excluding Powder Hole from the designated site in Chatham was that harvesting using hydraulic pumping could not be conducted in the manner required by the town as little to no area remained in the Powder Hole basin that met the water depth requirement at low tide.

Softshell clam harvesters in coastal New England typically use short hand-rakes, spend most of their time bent over at the waist or on hands and knees harvesting patches of shellfish, and traverse the exposed mudflats only to move among patches (Burger 1981, Leavitt and Fraser 2004). Shellfishers at the refuge usually land their boats adjacent to harvest areas, arriving around the midpoint of the falling tide. The boat is anchored and often grounds as the tide continues falling. Harvesters spend most of their time harvesting shellfish in localized patches. Harvesters can turn over approximately 40 m² of sediment in a low tide event (Leavitt and Fraser 2004).

Quahogs are hard-shelled clams that are often harvested using pumps that suspend the sediment and make the quahog float to the surface, where they are collected. Quahog harvesting using pumps does take place within open waters in the southwestern corner of the refuge. Quahogs are also harvested using bull rakes, often from shallow drafting boats in water, but in some intertidal areas of Monomoy NWR, quahog populations have established and can be harvested when the intertidal areas are exposed. The physical act is much like harvesting softshell clams, but the individual is usually standing upright and scrapes the sediment surface with a longer hand-held rake. Bull raking has become a common occurrence on the refuge (particularly near Minimoy Island) and has also occurred within Powder Hole in the past.



USFWS

Shell on the beach at
Monomoy National
Wildlife Refuge

Surf clam harvesting: Surf clam harvesting is not currently occurring on the refuge, although surf clams are present in the shallow water within the Declaration of Taking boundary along South Monomoy (map 2.9).

Mussel harvesting: The Town of Chatham allows mussel harvesting year-round, but the refuge has never been open to mussel harvesting. Small vessels drag dredges (no larger than 36 inches in width) through shallow areas at high tide to extract mussels from the sediment. These mussel beds are often vital for wintering waterfowl, especially common eider. Additionally, mussels are an important food for staging and migrating American oystercatchers and migrating red knots; staff have documented declines in both of these species in areas where mussel harvesting has occurred in recent years. Mussel harvesting has occurred in the open waters north of North Monomoy Island. We have no information on how often this has occurred, when it occurred, and how many people harvest mussels in this area. Mussel dragging occurred in shallow waters along the northwestern and the eastern flats of North Monomoy Island from 2008 to 2011 (map 2.9). Harvesters redirected their efforts from these areas in 2012 to take advantage of more productive flats located in Chatham Harbor. Mussel harvesting still occurs around North Monomoy Island, however, it is limited in scope compared with prior years (Gagne 2013 personal communication).

Bay scallop dragging: Scallop harvesting is conducted on and around the refuge from November through March. The refuge has never been open to scallop harvesting. Small dredges are dragged through dormant eelgrass beds where scallops reside. The Town of Chatham requires that all scallop dredge frames measure 36 inches or less in width. The use of rakes on dredge frames is prohibited to minimize disturbance to bottom substrate and eelgrass beds. Scallops are currently harvested from subtidal eelgrass beds located along the western side of North Monomoy Island, the Morris Island Channel, and the



northern end of the old Southway Channel (between North Monomoy Island and Nauset/South Beach; see map 2.9). Prior to the 1978 break, scallop dragging of subtidal areas occurred throughout the western boundary of the refuge; the shallow waters and sea grass beds were a highly productive area for bay scallops. It was theorized that, with the Southway closed off, the flats would slowly subside, eventually changing the western boundary back into a scallop fishery. However, if the 2013 break in Nauset/South Beach persists, the future direction of the fishery will remain uncertain.

Whelk (Conch) harvesting: Channeled whelk and knobbed whelk are harvested on and around the refuge from mid-April to mid-December (MDMF 2013a). The refuge has never been open for conch harvesting. Pots baited primarily with horseshoe crabs are used to catch whelk. The total reportable landings for whelk in SC 47 from 2007 through 2011 were estimated at approximately 144,622 pounds (table F.21; Massachusetts Division of Marine Fisheries; Dealer Reports, May 2010 and January 2013). During this period, whelk landings in SC47 have increased from a low of 18,611 pounds in 2007 to 42,982 pounds in 2011 (table F.21).

Razor clam harvesting: To the best of our knowledge, razor clam harvesting is not currently occurring on the refuge, but is occurring nearby. Also, razor clams have historically been harvested on the refuge and may be again in the future, as regional conditions change. There has been a robust razor clam fishery in Chatham in 2012 and 2013. Razor clams were harvested using salt injection in Wellfleet, Truro, and Eastham in 2005 and 2006. In this process, a salt solution is injected into the sandflats, and when razor clams expel themselves, a harvester collects the clams on the surface.

Oyster harvesting: We are not aware of any oyster harvesting occurring on the refuge; however, it is occurring in areas adjacent to the refuge as noted below under “Aquaculture.” We do not address oyster harvesting further in this plan.

Aquaculture: The Town of Chatham propagates and distributes, or seeds, shellfish spat adjacent to the Morris Island portion of the refuge. Young shellfish (quahogs, scallops, and oysters) are reared and moved from nursery sites and placed in subtidal areas, including sites adjoining the Morris Island unit of the refuge and in the Southway. The Town has not seeded any flats adjoining other portions of the refuge or within the Monomoy Wilderness for many years and has no such intentions, since shellfish populations continue to sustain themselves naturally in these areas (Moore 2011 personal communication). The Town of Chatham has not undertaken any softshell clam propagation or seeding to date.

Commercial Fisheries: Nantucket Sound supports a diversity of commercially harvested fish and invertebrate species such as flounder, sea bass, scup, mackerel, striped bass, bluefish, lobster, and squid. The marine fishery resources of Nantucket Sound are monitored and managed by the National Marine Fisheries Service—a branch of the National Oceanic and Atmospheric Association, the NEFMC and the MAFMC (established by the Magnuson-Stevenson Fishery Conservation Act), and the Massachusetts Division of Marine Fisheries. The ASMFC coordinates interstate management activities for wide-ranging species, including lobster, striped bass, bluefish, black sea bass and others) (ASMFC 2013).

Nantucket Sound, which encompasses waters within the refuge’s Declaration of Taking boundary, is designated as NOAA Fisheries Statistical Sampling Area 538 and Massachusetts Division of Marine Fisheries (MDMF) Statistical Reporting Area 10 (SRA 10). MDMF monitors State-permitted commercial fishing activity for certain fisheries and gear types in State waters within 3 miles from the coast. NOAA Fisheries has jurisdiction over federally permitted commercial fishing activities in all Federal waters between 3 and 200 miles

offshore. The 1983 Magnuson-Stevens Act was amended by Congress to give the Commonwealth of Massachusetts exclusive regulatory jurisdiction and authority throughout Nantucket Sound. NOAA Fisheries and MDMF collect independent and overlapping commercial fishing data. Federal permit holders are required by NOAA Fisheries to submit vessel trip reports that include information on fishing location, gear type, and species caught during each fishing trip (NOAA 2012). MDMF collects commercial harvest data through seafood dealer reports (Standard Atlantic Fishery Information System) and, until recently, annual catch reports identifying species caught and effort. Under the catch reporting system, fishermen were not required to report fishing locations for fin fish harvest, with the exception of certain gear types. Beginning in 2010, MDMF implemented a new comprehensive trip-level reporting system that collects harvest information from all State permit holders for all species. This change will help fill gaps in datasets, standardize data collection across State and Federal agencies, and facilitate data pooling between organizations (MDMF 2013b).

Some commercial fishing occurs in refuge waters, particularly in the southwest corner of the Declaration of Taking boundary; however, we currently have very little information on the extent. Commercial fishing is regulated by the Massachusetts Division of Marine Fisheries and the National Marine Fisheries Service. The waters of the refuge constitute less than 1 percent of MDMF SRA 10 (Nantucket Sound) and consequently the amount of commercial activity in this area is proportionately small. Commercial landings data for SRA 10 do not exist on a small enough spatial scale to accurately depict fishing activity specifically within the refuge Declaration of Taking boundary; nevertheless, landings data from SRA 10 are helpful for characterizing the commercial fishing industry in Nantucket Sound.

MDMF commercial fin fish landings from SRA 10 are reported for 2010 and 2011 to help characterize the commercial fin fish resource in Nantucket Sound. The data includes landings from Massachusetts permit holders as well as from NMFS vessel trip reports for individuals holding both State and Federal permits. The short timeframe of the dataset available under the State's new reporting system limits the ability to make inferences about long-term population trends. Despite this, these data establish a useful baseline for future use. The commercial fin fish landings reported by MDMF for SRA 10 for 2010 and 2011 averaged 963,195 lbs (436,897 kg). Fin fish catches during this time period were heavily composed of summer flounder, bluefish, scup, black seabass, striped bass, haddock, spiny dogfish, butterfish, cod, menhaden, and skate (table 2.17). These species represent approximately 93 percent of commercial fin fish landings reported by MDMF from SRA 10 in 2010 and 99 percent of the landings in 2011.

Table 2.17. Massachusetts Commercial Fin Fish Harvest (live pounds) in Nantucket Sound (SRA 10).

Species	2010	2011
Bluefish	89,437	190,577
Bonito, Atlantic	*	*
Butterfish	24,521	6,388
Cod, Atlantic	20,601	26,270
Cunner		*
Cusk	*	*
Dogfish, smooth	*	
Dogfish, spiny	27,503	113,957
Flounder, plaice, American (dab)	1,490	362
Flounder, sand dab (windowpane)	*	

Species	2010	2011
Flounder, summer (fluke)	238,061	287,087
Flounder, winter	16,602	1,558
Flounder, witch (gray sole)	4,838	1,102
Flounder, yellowtail	2,083	5,185
Goosefish	9,533	1,262
Haddock	33,482	12,001
Hake, Atlantic, red	*	
Hake, Atlantic, white	4,749	*
Hake, silver (whiting)	*	*
Herring, Atlantic, sea	*	
King whiting	*	
Mackerel, Atlantic	336	1,093
Menhaden	21,141	1,471
Perch, ocean (redfish)	*	*
Pollock, Atlantic	5,003	3,587
Puffer, northern		*
Scup	203,126	182,145
Sea bass, black	89,984	94,507
Sea robins		*
Skate, little	*	
Skate, winter	*	*
Skates	10,075	15,685
Striped bass	82,721	85,119
Tautog	2,170	5,377
Triggerfishes	*	
Tuna, albacore		*
Tuna, bluefin	2,377	1,825
Tuna, yellowfin		*

Source: DMF Trip-level and NMFS Vessel Trip Reports.

* Confidential

The commercial lobster fishery is managed from New Jersey to Maine by the ASMFC. The commission's interstate Fishery Management Plan divides Massachusetts into seven lobster conservation management areas that the Massachusetts Division of Marine Fisheries regulates (Dean 2010). Monomoy NWR is located within the Outer Cape Lobster Conservation Management Area (MDMF 2013a).

The lobster fishery in Nantucket Sound does not appear to be a major fishery. According to the Massachusetts lobster fishery statistic for 2006, more than 82 percent of the lobster harvest in territorial waters came from areas north of Cape Cod (Statistical Reporting Areas 1-7) (Dean 2010). Of the total commercial lobster harvest reported for Massachusetts coastal waters in 2006 (8,854,669 pounds), only 0.2 percent came from SRA 10.

The total State-reportable lobster landings for SRA 10 (Nantucket Sound) from 2001 through 2011 were estimated at approximately 265,779 pounds (table 2.18). During this period, lobster landings averaged 24,162 pounds, with a high of 41,741 pounds in 2002 and a low of 9,244 pounds in 2009 (table 2.18). It is not known how many lobsters are harvested commercially from within the refuge's Declaration of Taking boundary.

Table 2.18. Massachusetts Commercial Lobster Landings for SRA 10.

Year	SRA	Lobster Pounds
2001	10	23,828
2002	10	41,741
2003	10	23,862
2004	10	27,796
2005	10	30,200
2006	10	21,699
2007	10	18,037
2008	10	17,725
2009	10	9,244
2010	10	22,668
2011	10	28,979

Source: DMF Annual and Trip-Level Catch Reports

Commercial fisheries utilize a variety of gear types in Nantucket Sound. These are described below in table 2.19. The Cape Cod Commercial Fishermen's Alliance website provides a good overview of the region's commercial fishery and gear types employed (<http://www.capecodfishermen/the-fishermen>; accessed December 2013).

Table 2.19. Massachusetts Commercial Fin Fish Harvest Proportion by Gear Type in Nantucket Sound (SRA 10).

Gear Category	2010	2011
Gillnet	6.2%	13.9%
Hook	24.8%	32.0%
Other	1.4%	0.2%
Trap	8.1%	8.1%
Trawl	53.5%	40.5%
Weir	6.1%	5.3%

Fixed gear—Fish Weirs: Although historically used throughout Cape Cod, Chatham is one of the few Massachusetts towns to permit fish weirs, one of which continues to operate most years within the refuge's Declaration of Taking boundary. Weirs utilize a long narrow funnel-shaped net, set in shallow water using numerous poles. Fish pass into the net, but cannot find their way out. Fish weirs are typically used to capture squid, herring, and small baitfish, but can also impact fish-eating birds through depletion of prey, and sea turtles and marine mammals through entanglement. A loggerhead sea turtle was caught in a fish weir located within the Declaration of Taking boundary in 2007; staff removed the turtle from the net and transferred it to the Sea Turtle Salvage Network.

Fixed gear—Fish Pots: A limited number of fish pots occur within the refuge's Declaration of Taking Boundary, and are used to catch scup and black sea bass. Fish pots are similar in design to lobster pots and are usually fished singly or in trawls of multiple pots (not to exceed 2,500 feet in length).

Fixed gear—Lobster Pots: Commercial lobster pots occur throughout the refuge's Declaration of Taking boundary. Pots are fished as either a single pot per buoy, or strung together in "trawls" of multiple pots (not to exceed 2,500 feet in length). The season is closed annually from January through March (MDMF 2013c).

Fixed gear—Whelk (Conch) Pots: The commercial conch fishery is open from mid-April to mid-December (MDMF 2013a). Wood and wire pots are used to catch channeled whelk and knobbed whelk within the refuge's Declaration of Taking boundary. The pots are open at the top and are generally baited with horseshoe crabs. Pots are placed on sandy bottoms, usually near sea grass beds at depths of 1.5 to 27 m. Pots can be fished singly or in trawls consisting of up to 40 pots (Stevenson et al. 2004).

Mobile gear—Hook and Line (including handlines): Both striped bass and bluefish are commercially harvested in refuge waters. The striped bass commercial fishery is a hook and line-only fishery, with the season going from mid-July until the quota is filled (MDMF 2013d). The commercial bluefish harvest generally starts in Nantucket Sound with the return of migrating bluefish schools beginning in May and closes once the quota is met or the bluefish migrate southward again in October (MDMF 2013d). Commercial hook and line fishing for striped bass and bluefish occurs primarily in rips along the southern tip of South Monomoy; however, fish are also harvested in nearshore open waters throughout the Declaration of Taking boundary. Other species harvested commercially using hook and line gear (e.g., demersal longline) include black sea bass, cod, haddock, pollock, flounder, hake, and other groundfish, and dogfish (<http://www.capecodfishermen.org/the-fishermen>; accessed December 2013).

Mobile gear—Mid-water and Otter Trawls: Trawls are essentially large nets towed behind boats through the water at different depths, with large or coarse mesh toward the front that progressively decreases to finer mesh toward the rear of the net with the net kept open by trawl doors. The trawl doors and net opening function to herd fish into the finer meshed rear section of the net. Mid-water trawls target pelagic species suspended in the water column above the bottom, only infrequently contacting bottom substrates. Rope trawls are commonly used in the mid-water Atlantic herring and mackerel fisheries. Otter trawls target bottom-dwelling groundfish including cod, haddock, pollock, flounder, hake, dogfish, skate, and monkfish and therefore are in almost constant contact with the bottom. The 50-foot groundfish trawler the Joanne A III is the last remaining such vessel operating as a day boat from Chatham Harbor (http://cchfa.org/media/documents/MTF_Amaru_2.2013.pdf; accessed May 2013). Trawling does not likely occur within the Declaration of Taking boundary due to the shallow depths and heavy boating traffic.

Mobile gear—Troll Lines (commercial): These are a series of baited hooks or lures attached to two to four main troll lines by leaders, towed behind the tow vessel at different depths through the water column, rarely touching bottom, and separated using outriggers. Troll lining as described above does not occur within the Declaration of Taking boundary. However, some local fishermen sometimes use the term "troll line" when referring to demersal longline gear included in the above hook and line discussion.

Mobile Gear—Strike Nets and Gill Nets (commercial): Strike nets are set out in a circle, and then the boat runs in a circle to move the fish, into the net, which is hauled back immediately harvesting the fish alive. Strike nets are most commonly used locally to harvest bluefish during the warmer June 1 to October months (<http://www.capecodfishermen.org/bluefish>; accessed December 2013). Gill nets are anchored, or surface or drifting vertical walls of webbing, buoyed on top and weighted at the bottom, designed to capture fish by entanglement, gilling, or wedging (322 CMR 12.00(7)). Different mesh sizes are what determine the size classes of fish taken by these nets. Cod, haddock, flounder, pollock, hake, dogfish, skate, and monkfish are the species most commonly taken using bottom tending or “sink” gillnets in the Monomoy region during winter months (<http://www.capecodfishermen.org/the-fishermen>; accessed December 2013). Gillnet use is however prohibited in Nantucket Sound, including nearshore waters around Monomoy from April 1–November 15 (Chapt. 130, 322 CMR 4.09).

Placement of moorings (commercial and recreational): There are no existing moorings within the Declaration of Taking. However, in the summer of 2007, a commercial fishing boat (approximately 65 feet in length) placed a mooring block, which likely weighs about 5,000 pounds, on the west side of North Monomoy Island just outside the refuge boundary. The lack of mooring space within the Town of Chatham is a potential problem and we anticipate there would be interest in placing moorings within the refuge. This is not a use found appropriate for refuge waters, so moorings will not be allowed within the refuge boundary, except to assist refuge management activities.



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South Monomoy Island

Dredging: The Army Corps of Engineers permits limited dredging within the Declaration of Taking near the refuge boundary. The entrance to Stage Harbor in the northwestern corner of the refuge is dredged almost annually. There is some interest by some citizens and businesses to maintain through dredging the channel that separates Morris Island from North Monomoy Island. Where previously we had supported dredging the Morris Island channel, we are now concerned about adverse impacts to refuge lands from this activity. We must allow the Stage Harbor dredging to occur, and would evaluate all other requests for dredging in refuge waters to protect the Federal ownership interest of the refuge.

Beach renourishment: The Service allowed beach nourishment and revetment installation on the Morris Island portion of the refuge in the winter of 1998 and 1999. In 2005, the Cape Cod Commission approached the Service regarding beach renourishment on Morris Island, which we declined to support. However, the refuge beach on Morris Island has suffered significant erosion in the last 3 years. The Service has been meeting with the Army Corps of Engineers and the Town of Chatham to discuss the possibility of placing dredged material in the refuge, including possibly near Minimoy Island. The refuge would be willing to consider this activity if it would benefit beach nesting birds. In the last 5 years, Minimoy Island has annually hosted as many as 40 to 50 pairs of roseate terns, 1,000 pairs of common terns and piping plovers, American oystercatchers, and black skimmers.

Refuge Uses Found Not Compatible—Current

Horseshoe Crabs: During the 1990s, horseshoe crabs were harvested from Monomoy NWR. There was an active market during that time for using the crabs in the production of Limulus amoebocyte lysate (LAL) (Novitsky 1984), an extract of blood cells from the horseshoe crab developed by the biomedical industry to detect pathogenic endotoxins in injectable drugs and implantable

medical devices (Berkson and Shuster Jr. 1999). While (commercial) horseshoe crab harvesting for biomedical use was previously determined to be an appropriate and compatible use on the refuge, in 2002, based on new scientific data, all horseshoe crab harvesting was found incompatible with the refuge's purpose and mission and has not been allowed since. That compatibility determination provided a thorough synthesis of information available at that time. A summary of the justification for finding all horseshoe crab harvesting not compatible at Monomoy NWR is presented here.

Both types of harvest result in horseshoe crab mortality. Although crabs harvested for biomedical use are eventually returned to the waters, some mortality still occurs during the transport, handling, and bleeding process, and this mortality may be significant (Wenner and Thompson 2000, Walls and Berkson 2000, Leschen and Correia 2010). Additionally, horseshoe crabs' reproductive cycle makes them vulnerable to over-exploitation. The reproductive strategy of congregating in large numbers on beaches to spawn makes them easy targets for any harvester in both the intertidal and subtidal areas close to spawning beaches. Shallow water harvesters focus their efforts on high tides when the horseshoe crabs are moving into shallow waters to breed. The gentle topography of the west side of Monomoy NWR (including North Monomoy Island and the north tip of South Monomoy Island) allows horseshoe crab harvesters to easily collect animals in the intertidal areas on spawning beaches, and, in the subtidal areas, on their way to the spawning beaches. Because this species does not breed until reaching 9 to 10 years of age, declines in populations may not be realized for many years, and populations will be slow to recover from overharvesting.

Resulting loss of spawning crabs and eggs may impact migratory birds. Harvest for the biomedical industry and the commercial bait fishery both target gravid females that are collected as they approach, or while on, spawning beaches. It is likely that these uses result in a decrease in the number of horseshoe crab eggs that are deposited on the beaches in the year of harvest. In Delaware Bay, the reduction in spawning horseshoe crabs resulted in a 70 percent decline in horseshoe crab eggs (Tsipoura and Burger 1999), and this decline has been linked to subsequent declines in shorebirds on the New Jersey shores (Niles and Clark 1997). A number of species of shorebirds rely on Monomoy NWR during the spring and fall migration for habitat for feeding and resting, and we have confirmed that horseshoe crab eggs are one of the food items consumed by shorebirds at Monomoy NWR. While we have not identified all of the species that feed on horseshoe crab eggs on the refuge, this information is consistent with numerous studies from Delaware Bay that document the importance of horseshoe crab eggs to shorebirds during the spring migration. Given that Monomoy NWR is a critical spawning site for horseshoe crabs and is a critical migratory stopover site for shorebirds, it is likely that horseshoe crab eggs are an important food item in shorebirds' diets and a critical part of the food web on Monomoy NWR.

Refuge law enforcement has apprehended individuals harvesting illegally for bait within the refuge Declaration of Taking boundary. The National Park Service also does not allow harvesting of horseshoe crabs within their quarter-mile boundary of the Cape Cod National Seashore. The horseshoe crab harvest appropriateness and compatibility questions were again re-examined during development of this CCP in light of new scientific and monitoring information that has become available. A new finding that horseshoe crab harvest is not an appropriate use of refuge lands is included in appendix D.

Refuge Archaeological, Historical, and Cultural Resources

Cultural resources include a wide variety of objects and locations that are evidence of past human activities. These resources may exist below ground, such as archaeological sites, or may be encountered above ground, as with historic buildings and other structures, in addition to landscapes, viewsheds, or ceremonial sites. The Federal government is legally responsible for the preservation and management of cultural resources that are located on Federal lands, and must consider the potential impacts of Federal actions on cultural resources wherever they may exist.

Monomoy NWR contains a variety of known cultural resources dating as far back as Paleo-Indian cultures. These include Pre-Contact Native American sites on Morris Island, and the former locations of the historic Whitewash Village, seasonal cottages and camps, shipwrecks, and U.S. Coast Guard lifesaving stations on South Monomoy. The most well known cultural resource on refuge lands is the Monomoy Point Light Station, which includes the lighthouse, keeper's house, and small oil house, and is listed in the National Register of Historic Places. In general, archaeological resources on the refuge may be at risk due to erosion and natural forces.

Because very little of the refuge has been subject to systematic archaeological sampling, it is possible that many archaeological sites, both Native American and European-American, are currently unknown and await discovery. As sites are added to the inventory, the Service will have an enhanced ability to manage them as Federal regulations require.

Native American Archaeological Sites

No Native American sites have been recorded on South Monomoy or North Monomoy. During the Pre-Contact and Contact periods, Native Americans likely visited or settled upon the 8-mile peninsula from which the Monomoy barrier islands were later formed, but exposure to the elements and lack of vegetation has meant that local landforms (e.g., dunes and swales) were subjected to extensive erosion and movement. As a result, Native American archaeological deposits dating to the Pre-Contact period may be deeply buried on the two islands, or may have been deflated by erosion and no longer exist.

Two Native American sites have been recorded on refuge property at Morris Island. Both were shell middens of unknown date, reported by artifact collectors in the mid-twentieth century; little information currently exists for these sites. A third shell midden site, which produced pottery and triangular projectile points, was reported on Morris Island, outside of the refuge boundary. Evidence at this latter site suggests the island was occupied during the Woodland period, so it can reasonably be inferred that Morris Island, in general, witnessed Native American occupation during that time period, and that the Monomoy peninsula to the south was likely settled as well.

Two archaeological surveys related to Federal undertakings have been performed on refuge property. One small survey investigated a boat landing location on Morris Island, and testing was conducted at the Monomoy Point Light Station prior to the rehabilitation project at the light keeper's house. Neither survey recovered any Native American artifacts. No comprehensive archaeological study, such as an overview, has been conducted for the refuge as a whole. It should be assumed that the likelihood for unrecorded Native American archaeological sites is high in all undeveloped locations within the refuge, unless systematic professional sampling has demonstrated the absence of such resources. Areas of comparatively stable ground on the margins of estuaries and shellfish habitats are lands more likely to have been used in the past and represent zones of higher archaeological sensitivity.

The CCP and its management alternatives are required to comply with the National Historic Preservation Act (Sec. 106), which entails consultation with federally recognized American Indian tribes. The Mashpee Wampanoag

Historic Structures and Archaeological Sites

Tribe and the Wampanoag Tribe of Gay Head (Aquinnah) are the federally recognized tribes that are directly descended from the Native tribes that occupied southeastern Massachusetts and the Cape Cod region during the European contact period. The Service consulted with these tribes as part of the CCP process.

The following information was taken from the files onsite at the Region 5 U.S. Fish and Wildlife office in Hadley, MA.

Monomoy Point Light Station

In 1823, a lighthouse with an iron lantern room and wooden tower extending above the roof of a brick keeper's house was built on Monomoy Point (formerly known as Sandy Point). This lighthouse had a fixed white light illuminated by eight lamps with reflectors. The Monomoy Point Light, along with the Great Point Light on Nantucket Island, marked the entrance to Nantucket Sound for vessels in the Atlantic.

In 1842, I.W.P. Lewis, a civil engineer with the U.S. Lighthouse Survey, recommended replacement of the entire light station. In 1849, a new 40-foot cylindrical cast-iron tower was built (the existing lighthouse). The two-story wooden keeper's house was also constructed. According to an inspection report dated in 1850, the new iron lighthouse was "neither large enough, nor high enough, nor stiff enough." The lack of stability was due to poor footings. The earlier tower, which was masonry, began coming apart from the strong winds. The tower was later lined with brick to reduce the sway and provide insulation from the winter cold and summer heat.

The first lightship, Light Vessel No. 2, was placed at Pollock Rip in 1849 to assist the lighthouse on Monomoy Point in alerting ships to the dangerous currents. Light Vessel No. 2 was at Pollock Rip from 1849 to 1875. Eight lightships were on station at Pollock Rip from 1849 to 1969 (<http://home.comcast.net/~debee2/mass/Monomoy.html>; accessed February 2012).

The Lighthouse Board recommended upgrading the lighthouse to a second-order light in 1872 to better guide vessels through the waters; however, Congress never approved the recommendation, and the tower was instead painted red to increase its daytime visibility. In 1892, trusses were fastened to the tower in a short-lived attempt to increase stability and prevent vibration.

The opening of the Cape Cod Canal in 1914 enabled coastal vessels to avoid the dangerous waters around Monomoy Point. When the Chatham Light was refitted with increased power in 1923, the Monomoy Point Lighthouse was decommissioned. The government sold the station to George Dunbar, the first of several private owners, who made few changes to the property. By 1958, all equipment and glass in the light lantern had been removed. The property was sold to the Audubon Society in 1964 (Historic American Engineering Record).

The society made several improvements to the keeper's house, which served as a destination for guided tours viewing the extensive bird populations on Monomoy. The Service acquired the property in 1977.

The Monomoy Point Light Station is a structural complex listed on the National Register of Historic Places. Rehabilitation of its three structures, the 40-foot tall, cylindrical, cast-iron tower, keeper's house, and brick oil house, began in August 2010 (Oak Point Associates 2009). An archaeological investigation completed prior to the rehabilitation project found extensive evidence resulting from domestic occupation of the keeper's house (Binzen 2010 personal communication). The light station structures are on lands excluded from the Monomoy Wilderness when designated in 1970, but the site is largely surrounded by refuge lands designated as wilderness that must be crossed to access the structures.

U.S. Life Saving Stations

The waters surrounding Monomoy Point were historically the most hazardous in the Northeast, due to the shallow shoals, strong rip currents, and storms forming where the Atlantic Ocean meets Nantucket Sound. More than 3,000 shipwrecks have occurred in the waters surrounding Cape Cod over the last 300 years. After the U.S. Life Saving Service was established in 1872, three life-saving stations were built on Monomoy. Despite the lighthouse and the use of lightships, there were numerous additional shipwrecks off Monomoy Point.

The first lifesaving station was built on Morris Island near the current refuge administrative complex and designated as LSS #13 Chatham. The second lifesaving station, LSS #14 Monomoy, was located below Inward Point, near a cluster of cottages that were known as the Hammonds Bend Camps. A third station, Monomoy Point, was built at the southern tip of Monomoy, and subsequently expanded to a U.S. Coast Guard base complete with a residence and equipment building in addition to the original lifesaving station structure. None of the structures from the lifesaving stations still exist, although some scant surface evidence of the Coast Guard station buildings is still visible.

Seasonal Camps and Fishing Facilities

According to an account from Harry D. Ellis, who resided on the island circa 1900, “Between Inward and Monomoy Points stood three weir shanties, occupied by the crews which operated the weirs. The weirs were placed off the west shore (in Nantucket Sound) and as a convenience the boats and gear were kept at these shanties.” No evidence of the shanties of the Consolidated Weir Company is visible today. During the same period, the Monomoy Branting Club had at least three buildings that were used seasonally by sportsmen. These structures no longer exist.

Seasonal Cottages

The seasonal settlement at Hammonds Bend comprised about two dozen cottages and outbuildings. Families maintained a tradition of summer visits to these modest and remote abodes. Although these residences no longer exist, photographic evidence from the mid-twentieth century shows they were single-story dwellings sided with wood shingles.

Located closer to the Monomoy Point Light Station were other small cottages, also no longer extant, that made up the Jones Small Camp, the Edward J. Tripp Camp, and the John T. Mason II Camp.

Whitewash Village

During the early 1700s, a deep natural harbor at Powder Hole near Monomoy Point attracted a settlement that would come to be known as Whitewash Village. Local historians have reported various descriptions, although accounts of life for the historic village are scarce, as Chatham lost its town records to a fire in 1827 and its parish records during a fire at the Congregational Church in 1861 (Seufert-Barr 1995). The settlement was dealt a blow when its harbor was washed away during a hurricane around 1860.

The account from H. D. Ellis describes the community as it existed during the early 1900s:

At Monomoy Point itself was a cluster of dwellings occupied by the lobster fishing fraternity. Some were built along the shore of the Powder Hole, almost a circle where the tide flowed and ebbed and made a deep little body of water... I do not now recall the names of all the Pointers but on “this side” of the Powder Hole came first the abode of old Bill Bloomer. Next was our Ellis cottage, followed by houses of George Bloomer and young Bill Bloomer- both sons of old Bill. Then came the old store which in previous times had fitted out fishing

schooners... The old store was kind of a divider between the two sides... The Point Coast Guard Station had not been built during the earlier years of our stay, but the Monomoy Point Light was there.

All of these residents (lobster fishermen) were for the summer only. We are speaking of the era when all the boats had sail power only, making it necessary to live as close as possible to where the [lobster] pots were set. These years were the late eighteen hundreds and early nineteen hundreds... The houses at the Point were built of lumber and laths which were picked up along shore. At that time there was a considerable amount of flotsam and jetsam which came from wrecked vessels and in some cases where the deck load was thrown or washed overboard. The finished lumber came from Chatham.

A report to the Commonwealth of Massachusetts on the status of the quahog fishery described the Powder Hole during the period 1905 to 1910 when it served as a field laboratory for early quahog culture and growth experiments (Belding 1912), including a site map (figure 2.14), as follows:



Sanderlings

During the period from 1905 to 1910 [quahog] growth experiments were conducted in the Powder Hole...The natural aquarium of several acres, teeming with shellfish life, was leased for experimental purposes by the Commonwealth, and proved by its protection and variety of natural conditions in a limited area, a most satisfactory location for a quahog investigation. In 1906 a small shanty was fitted up as a laboratory, and a raft of 20×10 feet was anchored in the deeper water of the Powder Hole. Growth experiments for a period of four years were conducted by suspending boxes of sand from the raft at various depths, while several methods of spat collecting were tried. In the flats and waters of the Powder Hole, under different conditions as regards current, soil, and depth of water, a number of cultural experiments were established.

In former years the Powder Hole was a spacious harbor where hundreds of vessels could anchor, but the sand bars have so shifted that at the present time nothing remains but an almost enclosed body of water of perhaps 3 acres, connected to the ocean on the bay side by a narrow opening through which a dory may enter at high tide. The opening changes constantly, owing to the shifting nature of the sand, and has successively worked from the south to the north side, closed and reopened again at the south at intervals of one and a half years. A large part of the original harbor is now dry land or salt marsh, while on the north and west side is a sand flat of 3 acres, which until 1910 contained an abundant quantity of softshell clams. The harbor itself is slowly diminishing in size, due to the encroachment of the sand, and will doubtlessly eventually become a small pond, not connected with the ocean.

The water on the north and west sides averaged 15 and 18 feet in depth, gradually shoaling to the south and east. In the shallow water the soil was covered with an abundant growth of eelgrass. The rise and fall of the tide was about 1 ½ feet on the average, but extremely erratic, as the force and direction of the wind and position of the opening were important in determining the amount of water passing through the narrow inlet.

The channel connecting the Powder Hole and the ocean became blocked during the summer of 1908, with the result that there was a stagnation of the water in the Powder Hole during part of the growing months.

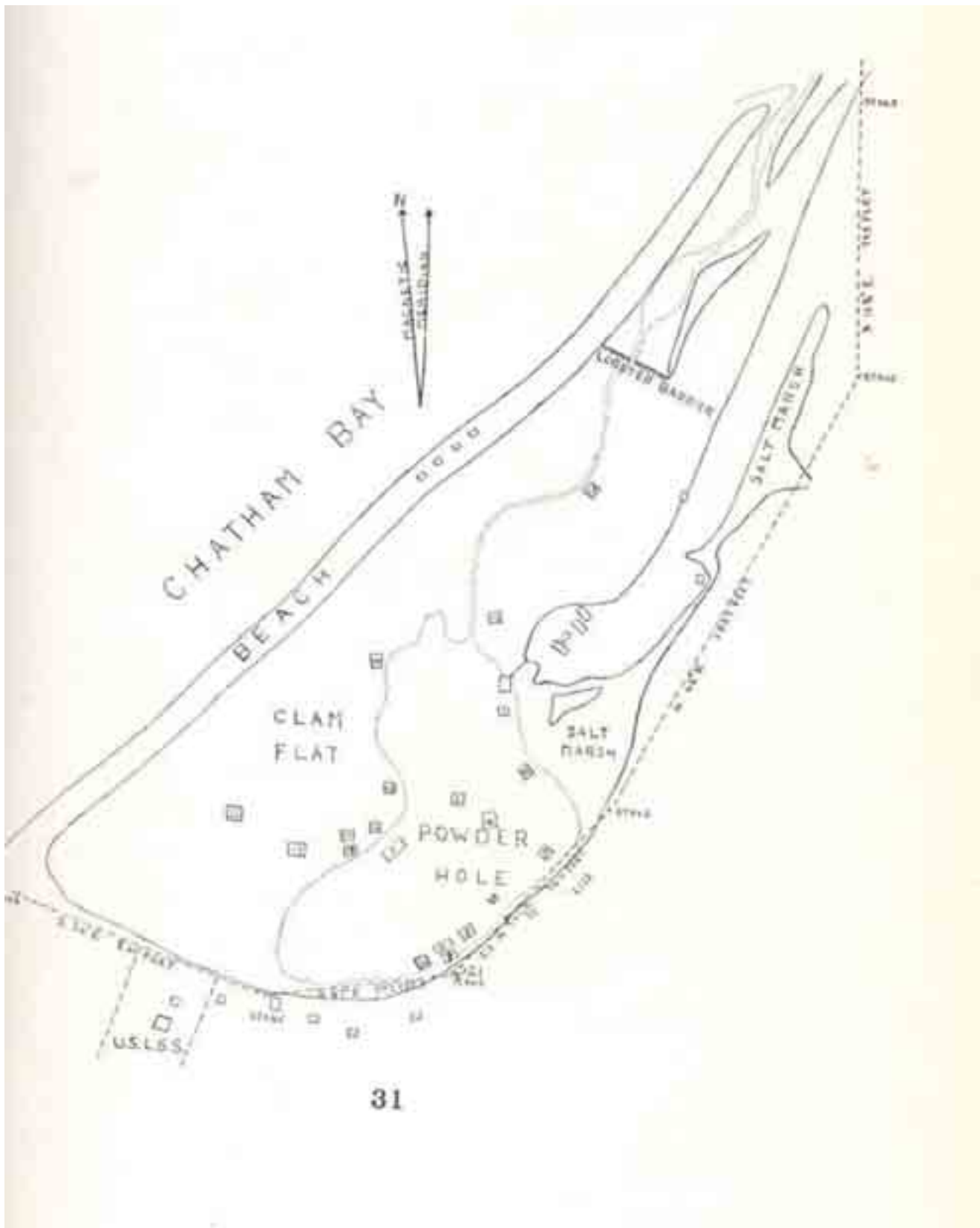


Figure 2.14. Powder Hole, Circa 1910 (Belding 1912).

Today, little evidence of the historic Whitewash Village exists on the ground surface because the buildings had minimal foundations and the vicinity has been affected by sand activity such as erosion and dune formation. A variety of archaeological deposits and features may be preserved beneath the ground surface, but also have been subject to wind and erosion. All the buildings at Whitewash Village (consisting of approximately one dozen cottages and outbuildings) were either destroyed by storms or demolished by the Service after establishment of the Monomoy NWR. No formal study has been conducted to map and inventory historic archaeological resources at the refuge. The historic archaeological record at the refuge may possess research value as an opportunity to investigate an early American fishing village, if any associated archaeological resources still possess integrity.

Regional Socioeconomic Setting

Economic Overview

The Town of Chatham is known as a resort, retirement, and artistic community. Chatham, one of the older townships of Cape Cod, was settled in 1656 by a handful of Pilgrims, whose surnames still dominate the Town's census list. The town was later incorporated in 1712. Originally a farming community, its inhabitants found deep-sea fishing more lucrative. Fishing has been a part of Chatham's cultural identity for over three hundred years. Abundant stocks of groundfish such as Atlantic cod, haddock, redfish, hakes, and flounders supported Chatham's fishing industry throughout much of its history. In the early 1700s, Chatham's fleet was one of the largest in New England, consisting primarily of small day boats fishing close to shore for cod, mackerel, and shellfish. In these early years, fishing fueled the local economy and many residents either fished or were employed in trades related to fishing (http://www.wickedlocal.com/chatham/news/x422900698/Smaller-fleet-fewer-fish-but-after-300-years-fishing-still-defines-Chatham?zc_p=1#axzz2PSYG7wUH; accessed April 2013).

By the late 19th and 20th centuries, large fleets of schooners sailing from Gloucester and Boston targeted cod and other groundfish along offshore banks from Cape Cod to Newfoundland. The majority of cod were preserved with salt prior to the vessels returning to port. Overfishing by the early hook-and-line fleets was occurring at this time and stocks of Atlantic halibut and other species began to decline. At the turn of the 20th century technological innovations such as refrigeration and railroad transportation expanded the commercial market for fresh fish. Steam-powered trawl vessels quickly replaced sailing schooners. At the end of World War I, following the introduction of the diesel powered trawler, the number of targeted species increased. Trawlers shifted from harvesting primarily cod to harvesting species such as haddock, redfish, and flounders throughout the 1930s, 1940s, and 1950s.

In the early 1960s, groundfish stocks faced additional exploitation from factory-based trawlers from eastern Europe and Asia that harvested unsustainable amounts of haddock, hake, and herring from New England waters. A quota-based management system was instituted in 1970 to regulate foreign catches and reverse the severe declines experienced by most groundfish species during this period. The Magnuson Fishery Conservation and Management Act of 1975 officially ended the participation of foreign fishing fleets in U.S. waters within 200 miles of the coast. Following the elimination of the foreign fleets, some stocks rebounded, only to be overfished again by domestic fleets. Stock biomasses of many groundfish reached record lows in the early 1990s, prompting the passage of the Sustainable Fisheries Act of 1996, which requires that overfished populations be restored (<http://www.nefsc.noaa.gov/history/stories/groundfish/grndfsh1.html>; accessed April 2013).

The ability of the Chatham fishing fleet to survive in a constantly changing industry is a testament to its adaptability. Following record low numbers of groundfish in the early 1990s, some species began showing signs of recovery in 2003, when 2.8 million pounds of groundfish were landed at the Chatham Fish Pier (figure 2.14). Since 2009, however, groundfish landings have plummeted and less than 700,000 pounds were landed at the pier in 2012 (less than 30 percent of the cod quota was caught). In the absence of the more lucrative groundfish species, the fleet has been forced to target less profitable species like skate and dogfish. Dogfish landings have drastically increased from 232,360 pounds in 2005, to over 3.3 million pounds in 2012 (figure 2.15). Together, skate and dogfish represented 82 percent of the total 2012 landings at the Chatham Fish Pier (<http://www.ccchfa.org/media/documents/CCC.FutureofChathamFishing.2.28.13.pdf>; accessed April 2013).

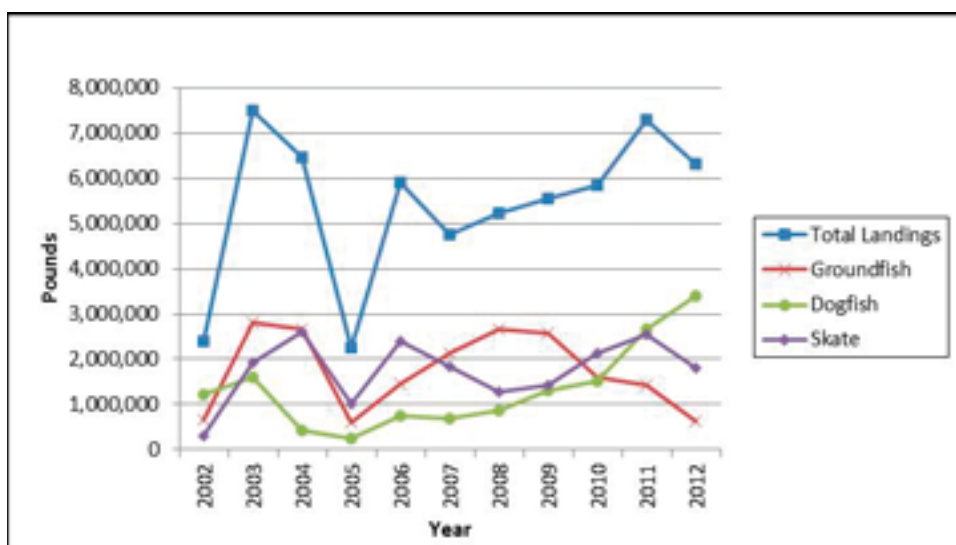


Figure 2.15. Chatham Fish Pier Landings 2002 to 2012. Source: Chatham Fish & Lobster Company Inc. and Nantucket Fish Company Inc.

Population Demographics

Although the population of Massachusetts grew by approximately 3 percent between 2000 and 2010, the County of Barnstable had a decrease in population by the same amount (U.S. Census Bureau 2010). At the same time, the region became more diverse, with an increase of 56 percent of people who identify themselves as Hispanic or Latino, and a 4 percent decline in the number of people who describe themselves as white (U.S. Census 2010). The number of Cape Cod residents identifying themselves as Asian increased by 63 percent, the Native American population increased by 7.2 percent, and the black population by 2.3 percent (U.S. Census Bureau 2010).

The most significant trend in the Cape Cod region is the decline in the younger demographic—a decrease of 21.09 percent in persons “18 and under” between 2000 and 2010. According to the U.S. Census Bureau (2010), approximately 2.6 percent of the population in Chatham CDP is 5 years of age or younger, approximately 9.8 percent of the populations is between the ages of 5 and 19, approximately 88.6 percent is age 18 years or older, and about 40 percent of the area’s population is 65 years or older.

Employment rates in Barnstable County decreased by approximately 3 percent between 2000 and 2010. The average per capita income in 2010 for Chatham is \$57,006; Barnstable County has an estimate of \$33,435, which is equivalent to the per capita income for the State. The average family income in Chatham is

\$163,316—a difference of 60 percent compared with the State’s average family income of \$64,509 between 2006 and 2010 (U.S. Census Bureau 2010).

In 2010, Chatham had a local population of around 1,400. Its labor force is about 40 percent of its population and in 2010, nearly 9 percent of its labor force reported being unemployed. The largest employers in the area, in terms of employment, were (1) the arts, entertainment, recreation, and accommodation and food services; (2) finance and insurance, real estate and rental and leasing, and educational services; and (3) health care and social assistance (U.S. Census Bureau 2010). Together, these three industries employed about 43 percent of the total workforce. Construction and retail trade also employed about 20 percent of total employment, a significant portion of the labor force.

**Economic Sectors,
including Recreational and
Commercial Activities**

As previously described, the refuge consists of lands located on Morris Island, North Monomoy Island, South Monomoy, and open waters within the Declaration of Taking. The visitor contact station on Morris Island is accessible by car. North Monomoy Island and South Monomoy, the majority of which is designated as wilderness, are accessible primarily by ferry or private boat. Motor boats are allowed in the Monomoy wilderness area because the Wilderness Preservation Act allows the use of motor boats to continue where these uses have already been established and deemed desirable by the Secretary of the Interior (16 U.S.C. § 1133(d)(1)). There is no supply of potable water on the refuge. The refuge is open year-round, with most visitation occurring during the summer tourist season from late spring to early fall. The refuge offers wildlife viewing sites, hiking trails, and extensive fishing opportunities.

Most refuge visits, especially those to the Monomoy Islands, occur between May and October, peaking in June, July, and August. The heaviest visitation is at the headquarters complex and the point on Morris Island, near Godwit Bar on North Monomoy Island, the southern third of South Monomoy, and the northern tip of South Monomoy (Inward Point). In recent years, surf casters have utilized most of the edges of North Monomoy Island and the waters surrounding the northeast end of South Monomoy. Popular shellfishing areas change even more frequently, but the flats on the north end of South Monomoy, the south end of North Monomoy Island, and the east side of Minimoy Island have been used the most since 2007. Birdwatchers who frequent North Monomoy Island often utilize the access corridor that bisects the salt marsh and leads to expansive flats on the west side where shorebirds forage (Koch 2011 personal communication).

Additionally, many summer visitors come to the refuge primarily for sunbathing and swimming. Popular areas include the beaches of Morris Island, the east side of North Monomoy Island adjacent to the boat channel, sandbars between the islands, and the beach just west of Powder Hole.

In 2012, the refuge reported that a total of 33,150 people visited the refuge. The expenditures associated with the recreational activities of Monomoy visits, including fishing, wildlife viewing, and beach and water recreation contributed slightly less than \$260,000 to regional output (Maillett 2012). Monomoy NWR and adjacent Nauset/South Beach are unmatched on the Cape for opportunities to view a wide variety of migrating shorebird species. In addition, the wilderness status and difficulty of access create a unique environment for visitors to experience its solitude and naturalness. The variety of Monomoy NWR wildlife attracts birdwatchers from throughout the Northeast, and many birding clubs and other outdoor recreational groups organize field trips to Monomoy NWR. Two for-hire vessel operators have provided ferry services to the refuge and seal tours for several years. In addition to the wildlife watching cruises offered by Outermost Harbor and Monomoy Island Ferry, both the Massachusetts Audubon

Society and the Cape Cod Museum of Natural History offer longer guided trips. These groups plan seasonal visits for small groups (i.e., fewer than 30) primarily to observe migratory shorebirds. Participants pay a fee to the organizations, which then arrange for transportation to the refuge and an interpretive guide.

Shellfishing

Over the course of the last 20 years, Chatham has been one of the top shellfish producing towns in the Commonwealth of Massachusetts. Collectively, Chatham has a total of 101,763 acres available for shellfishing in 17 State-designated shellfish areas. Several of these areas are commonly harvested for softshell clams and quahogs during low tide periods. Of these areas, Monomoy Island (SC47) is the largest designated area at 37,831 acres, representing nearly 80 percent of the tidal shellfish areas. In fact, the Monomoy area, which has no seasonal closures, has a greater relative importance in the entire area. In contrast, many of the tidal areas within the town are conditionally approved for harvest. This usually means that these areas will be closed to harvest if fecal coliform bacteria levels exceed National Shellfish Sanitation Program standards.

In 2011, nearly 1.4 million live pounds of shellfish were harvested in the Chatham area, and more than one-half of the harvest originated from Monomoy. About 50 percent of the Monomoy harvest was northern quahogs (786,632 live pounds). In 2011, Monomoy shellfishermen also landed more than 20,655 pounds of bay scallops, 10,449 pounds of soft-shell clams, and 42,982 pounds of whelks.

A brief description of the types of shellfish harvested in Chatham waters follows.

Mussels

Mussel harvesting has occurred in the open waters north of North Monomoy Island. We have no information on how often this has occurred, how many people harvest mussels, or what the economic value of the mussel harvest is. Over the past 20 years, on average, the typical mussel harvest has been about 28,000 bushels (Maillett 2012). Mussel harvest was the primary reason for the record total harvest levels in 1990, 1991, 1992, and 2008. In the recent past, most of the mussels were harvested out of Pleasant Bay. Mussels have also been harvested out of Chatham Harbor.

Softshell Clams

In 2002, the peak year for soft-shell clam harvest in Chatham, the total amount of harvest was 78,000 bushels (Maillett 2012). According to the Shellfish Constable's annual reports, the majority of the harvest, not only in the peak year of 2002 but for all years, came from Monomoy and Nauset/South Beach. Since that peak year though, harvest levels have dropped precipitously. In 2009, the total amount of softshell clams harvested was 4,000 bushels, about only 5 percent of the peak harvest in 2002. In 2011 the harvest of softshell clams rebounded to nearly 18,000 bushels. According to the 2010 Shellfish Constable report, the increasing harvest of softshell clams is now primarily coming out of the north side of town (Chatham Harbor and Pleasant Bay). The recent decline in the harvest of softshell clams has been attributed to the changing geophysical conditions of South Monomoy.

Quahogs

In contrast to the softshell clams, quahog harvests have shown a steady and stable increase between the years 2001 and 2008, and have pretty much stayed between 10,000 and 20,000 bushels per season (Maillett 2012). The average annual harvest over the past 20 years has been about 14,000 bushels. Common Chatham shellfish areas where quahogs are harvested include Monomoy, Oyster Pond, and Mill Pond. Oyster Pond, however, is conditionally approved by the State and subject to seasonal closures.

Bay Scallops

Bay scallops are typically not as plentiful in Chatham's waters compared to other species. Typically, annual harvest levels are around 500 bushels (Maillett 2012), although there can be "spikes" in scallop landings affected by market values and local abundance. For example, 2009 was a banner year when the town reported more than 10,000 bushels of bay scallops were harvested. Not since 2001 has the town reported a bay scallop harvest greater than 1,000 bushels. These scallops were mainly harvested from the "southway" between Nauset/South Beach and Monomoy, the outer part of Stage Harbor, and Oyster River.

Commercial Fishing

There is some commercial fin fishing occurring in refuge waters, particularly in the southwest corner of the Declaration of Taking. Fishermen have historically harvested striped bass, bluefish, black sea bass, scup, fluke, lobster, whelk, and sea clams in Nantucket Sound and the subtidal waters of the refuge. Because the open waters of the refuge constitute a minor portion of the fishing zones, the amount of activity in this area is small and the majority of the fish in this area are harvested though rod and reel. We have no information about the economic value of this catch.

Guided Recreational Fishing

Monomoy NWR provides exceptional fishing opportunities. Sport fishing activities on the refuge have been a significant factor in the local economy; recreational fishing and guided excursions to the Monomoy Refuge in 2012 contributed close to \$100,000 in visitor spending to the local economy (Maillett 2012). Guide fees vary by the type of fishing and amount of time on the water. Typical rates for fishing the flats from a boat for a party of one or two anglers ranged from \$375 for 4 hours to \$575 for an 8-hour session. Wade fishing tends to cost less, from \$250 for a 6-hour trip to \$300 for an 8-hour trip, plus ferry fees (\$15). Guide fees do not include tips, which typically run about 20 percent (<http://www.fishingthecape.com>; accessed February 2011).

Transportation and Wildlife Watching Services

There have been two principal ferry operators who provide the public transportation to Monomoy NWR and the flats—Monomoy Island Ferry and Outermost Harbor. In addition to providing transportation to the refuge, these ferry operators have also provided boat tours around the island for wildlife viewing (primarily seals).

*Seals on South
Monomoy Island*



USFWS

Monomoy Island Ferry

The Monomoy Island Ferry Company has the Rip Ryder, a 32-foot, twin engine power boat with a capacity of 20 passengers in addition to the captain. The company has been operating for over 20 years and boards passengers right on Morris Island, outside refuge headquarters. During the last decade, the Rip Ryder shuttled both fishing passengers and birders back and forth to North Monomoy Island and Nauset/South Beach for a fee. This service was effectively suspended in 2012. The company now primarily offers 90-minute seal cruises, which depart the refuge at 9:30 a.m., 11:30 a.m., 1:30 p.m., and 3 p.m. In 2012, the charge was \$35 per adult and \$30 per child. Monomoy Island Ferry will also shuttle birding group trips to South Monomoy, using either a small vessel for groups of six or fewer or a larger vessel for groups of 12 or fewer, at a charge of \$360 for the small vessel and \$720 for the larger vessel (<http://www.monomoyislandferry.com/>; accessed February 2013).

Outermost Harbor

Outermost Harbor Marine operated a shuttle to both North Monomoy Island and Nauset/South Beach for fishermen, birders, and recreationalists. In 2009, the charge was \$20 per person for shuttle service to Monomoy NWR. Outermost Harbor Marine operates out of the marina off Seagull Road, approximately ½ mile south of Chatham Light (<http://www.outermostharbor.com/>; accessed March 2011). In 2013, Outermost Harbor Marine suspended its water taxi service to the refuge for business reasons (<http://outermostharbor.com/water-taxi/>; accessed February 2013).

Overall, recreational visits to the refuge contribute about \$1,500,000 to the town's economy (Maillett 2012).

Refuge Contributions to the Local Economy

The operation of the National Wildlife Refuge System not only provides wildlife with habitat but also provides visitors with opportunities to enjoy a variety of wildlife-dependent recreational and educational activities. Where it contributes to the purpose of the refuge and is compatible, an economic use such as haying or timber removal may be allowed. The operation of an individual refuge is much like that of any small business. Refuge budgets are spent on salaries, expenses, and payments, much of which are spent within the local community.

In fiscal year 2012, Monomoy NWR employed a refuge manager and two permanent biologists, one full-time term wildlife biologist, one part-time student employee, two seasonal biological technicians, and several seasonal interns. Salaries for the year were about \$235,000 for the full time workers and about \$80,000 for the seasonal workers.

The Refuge Revenue Sharing Act of 1935, as amended, provides annual payments to taxing authorities, based on acreage and value of refuge lands. We have contributed refuge revenue sharing payments to the Town of Chatham since the refuge was established. Money for these payments comes from the sale of oil and gas leases, timber sales, grazing fees, the sale of other refuge system resources, and from congressional appropriations. The actual refuge revenue sharing payment varies annually because Congress may or may not appropriate sufficient funds to make full payment. Payments are based on one of several formulas. In Massachusetts, the payments are based on three-quarters of 1 percent of the appraised market value. The purchase price of a property is considered its market value until the property is reappraised. The Service reappraises their properties every 5 years.

The actual Refuge Revenue Sharing payments made to the Town of Chatham by the refuge for the last 6 fiscal years (FY) are shown in table 2.20. The most recent refuge revenue sharing payment was based on 7,604 acres. At the next reappraisal, the acreage will increase due to the attachment of Nauset/South Beach to South Monomoy Island.

Table 2.20. Refuge Revenue Sharing Payments for Monomoy NWR.

Fiscal Year	2007	2008	2009	2010	2011	2012
Payment	\$32,805	\$25,452	\$23,917	\$22,533	\$24,146	\$22,690

Monomoy NWR also spent approximately \$63,000 (FY 2011) annually on materials and services to operate the refuge (Maillett 2012). Again, most of this money was spent locally.

Refuge Administration

Refuge Establishment and Special Designations

Monomoy NWR was established on February 10, 1944 through a Declaration of Taking by the Secretary of the Interior (District Court of the United States for the District of Massachusetts, Misc. Civil No. 6340). This taking extends from the mean low water line on the eastern shores of the refuge and to an area within Nantucket Sound identified by latitude/longitude coordinates on the western side. Included within the Declaration of Taking are all the lands lying above mean low water, including a portion of Morris Island, all of Monomoy Beach, North Monomoy Island, and South Monomoy, Shooters Island, all land covered by the waters of landlocked ponds, and all islands, islets, sand bars, and tidal flats lying in Nantucket Sound, Chatham Bay, and Stage Harbor, all lying within the specific exterior limits. This rough acreage was estimated in 1944 to be about 3,000 acres, which roughly corresponded to the area above mean high water, although the written description of the entire Declaration of Taking area well exceeded that amount as it used some explicit boundary points and mean low water along the eastern shore. The western boundary of the Declaration of Taking was established in recognition that geophysical processes would change the shape and location of the refuge, and all lands and waters above mean low tide, as well as other features that are submerged within the fixed western boundary, were to remain as part of the Monomoy NWR. This land was acquired, “together with all accretioned land and singular water and riparian rights and other rights, tenements, hereditaments and appurtenances thereunto belonging or in any wise appertaining.” The Declaration of Taking was upheld by the District Court of the United States on June 1, 1944. It is noted that the official acreage of the refuge was not accurately determined at the time of taking, which significantly exceeded 3,000 acres.

The boundary is fixed by specific coordinates on the north, west, and south and is ambulatory on the east. Because of this, the size of the refuge changes over time as lands move, erode, or accrete. In 2000, a global positioning survey along the mean high and mean low water lines was conducted. The acreage determined to be above the high water line was 1,838 acres, the acreage above the mean low water line was 3,599 acres, acreage submerged under water was 4,005 acres, and the total acreage within the Declaration of Taking was 7,604 acres. In 2001, the Service’s Chief Surveyor reviewed the survey and found that the map was an accurate depiction of the conditions as of September 15, 2000 (Kopach 2002). In 2013, the refuge boundary was expanded to include an area on Nauset/South Beach. This additional 717 acres brings the total refuge ownership to 8,321 acres. Coincidentally, in 2013 a breach occurred on Nauset/South Beach in the vicinity of this new boundary.

Submerged lands within the fixed boundary are included based on historical records that indicate an emphasis on controlling and restoring these lands due to their value for waterfowl. The extensive sea grass beds on the west side of Monomoy Island were recognized for their value to wintering waterfowl, in particular. Throughout the initial designation process for the refuge, the Monomoy area was recognized as an “outstanding waterfowl area” and as “one of the finest shorebird beaches in North America” (Salter 1938) and for the eelgrass

(*Zostera*) beds in shoal waters northwest of Inward Point on the Common Flats (Griffith 1938) that were described as “dense” beds in 1929 (Hotchkiss and Ekvall 1929). The biological values of this area helped define the refuge boundary. Deeds are to be interpreted consistently with the framer’s intention, and it is clear from the historical records that areas containing sea grasses formed an important basis for establishing the refuge, therefore, including these submerged lands within the fixed western boundary is appropriate.

Also within the Declaration of Taking are transitory rivulets that run through the refuge or may form channels or bays stretching across areas of lower water. Based on geomorphological advice concerning the integrity of an intertidal system and upon approaches based on international treaty and Supreme Court cases, the surveyors drew straight lines across the “headlands” of such features rather than tracing mean low water up and through these landforms. We believe this is the correct cartographic approach to follow.

Additionally, the transfer of submerged lands to the Commonwealth of Massachusetts as a result of the 1953 Submerged Lands Act did not include lands within the exterior perimeter of the Declaration of Taking. These lands have been subject to Federal jurisdiction and control since refuge establishment, although actual refuge management of these submerged and tidal lands has been limited. In subsequent litigation by the Commonwealth of Massachusetts on the 1953 Submerged Lands Act, Massachusetts claimed all of the waters of Nantucket Sound, which included the waters west of Monomoy within the Declaration of Taking. The Supreme Court held that the submerged lands west of Monomoy Point were not Massachusetts’ internal waters at the time of the formation of the Union. Therefore, the submerged lands within the Declaration of Taking were already acquired as federal land, excepted from the Submerged Lands Act, and subject to federal jurisdiction and control when the Commonwealth received the surrounding lands in 1953.

Included in this area, and therefore falling under refuge jurisdiction, is the area of open water in the Morris Island channel that was land when the refuge was established. This area clearly lies within the coordinates of the Declaration of Taking.



USFWS

Salt pond along Morris Island Trail

The east boundary of the refuge is an ambulatory boundary, meaning it moves as the mean low water line moves. Monomoy Island itself has shifted west since the refuge was established; as described earlier in this chapter, it has split into North and South Monomoy Islands. This is a dynamic system, so the eastern boundary will never be static, and refuge acreage figures will change over time as land and water characteristics change.

Approximately 717 acres of Nauset/South Beach became part of Monomoy NWR as a result of a long period of coastal accretion and erosion. However,

before the new cut in Nauset/South Beach occurred, it had attached to the refuge in 2006. The Southway, a channel between South Monomoy Island and Nauset/South Beach, had been filling in slowly for several years. This attachment, the result of many years of sand movement southward from Cape Cod Atlantic-facing sandy beaches to the north, created complications related to property boundaries

and jurisdictional issues. The Declaration of Taking defined the Monomoy NWR eastern boundary (Atlantic Ocean side), as mean low water. This definition served as long as Monomoy remained an island, but once Nauset/South Beach attached to it, a new boundary reflecting the joinder of Nauset/South Beach and South Monomoy Island needed to be identified. Further complicating the boundary determination is that South Beach is a continuation of Nauset Beach, which was the original landform forming the southern boundary in the designation of the the National Park Service's Cape Cod National in 1960. Furthermore, national seashore designation extends $\frac{1}{4}$ mile out from the mean low water line so now the Cape Cod National Seashore jurisdiction overlays Monomoy NWR as well.

The Town of Chatham, the National Park Service, and the U.S. Fish and Wildlife Service all had interests and rights in the ownership and management of parts of Nauset/South Beach at the time the final attachment occurred. In 2007, an agreement (called the "handshake agreement") with the Town of Chatham, the National Park Service, and the Service was temporarily established for management of the joinder area. The attachment point, or "thread," was vague, but the three entities agreed that the Service would manage all lands west of the thread and the town would manage all lands east.

In 2008, a signed memorandum of understanding (MOU) formalized the handshake agreement among the National Park Service, the Service, and the Town of Chatham. The MOU contained an agreement among the parties to establish an administrative boundary for use in determining jurisdictional authorities among and between parties. This boundary was intended to be temporary until a permanent solution regarding Department of the Interior jurisdiction (the overlap of the Cape Cod National Seashore onto Monomoy NWR) was resolved.

Since the establishment of this short-term agreement in 2007, the land connection grew longer and wider. It became very difficult to define a line that demarcated the point of physical connection at mean low tide. Because all parties to the MOU maintained close communication and worked together, the difficulty defining a line demarcating this changing area did not become an issue throughout the 5 years of the agreement. However, at the expiration of the MOU in January 2013, we had not reached agreement on how to define a new boundary. The original agreement inadvertently erred in the designation of an administrative boundary. Later, all three parties to the MOU could not agree on where the new boundary, reflecting the geomorphological changes that had occurred over the past 5 years, should be. This issue became moot, however, in early 2013 when South Monomoy became an island once again. Approximately 717 acres of Nauset/South Beach attached to South Monomoy and are now part of the refuge. There is an additional area to the west of Nauset/South Beach that could fall under the jurisdiction of the Service as well. It has not been determined yet if a new agreement is needed and, if so, who will be the parties to the agreement.

The northern part of Nauset/South Beach is still connected to the Town of Chatham mainland. Interestingly, the February 2013 breach in Nauset/South Beach occurred exactly where the Service would have indicated the revised boundary should be. The administrative boundary was inadvertently decided based on riparian (riverine) principles, but those are not appropriate in this littoral (ocean) environment. When there is a coastal accretion affecting multiple landowners, the principle of equitable division applies. Application of this principle retains direct access for all littoral owners to the shoreline directly across from their upland property.

Before the February 2013 break, we had determined that the legal doctrine of equitable division (see *Lorusso vs. Acapesket Improvement Association, Inc.*

408 Mass. 772, 1990) should define the new refuge eastern boundary. This would be in accordance with Massachusetts land law for defining changing boundaries in coastal locations. The Massachusetts Supreme Judicial Court, in deciding the *Lorusso* case, stated [that] “when two or more littoral owners have rights to simultaneously formed accretions, the rights of the owners in the accretions are to be determined by the doctrine of equitable division.” According to the court, “the object of apportioning simultaneous accretions among lots of littoral land is to give each owner the same proportion of the new waterfront that he would have had if the accretions had never occurred” and “division on a non-navigable river frontage is so made as to give each relatively the same proportion in his ownership of the new river line that he had in the old.” The administrative boundary defined in the now expired MOU did not accurately portray the changing legal boundary, nor did it supersede existing legislative boundary definitions or land ownership interests. The principle of equitable apportionment or equitable division involves retaining direct access for each littoral owner to the shoreline directly across from their upland, so the line of division is made in an east-west division. Based on existing refuge ownership near the northern part of the refuge, this line occurs exactly where the break occurred in February 2013.

The basis for our determination regarding our ambulatory eastern boundary, upheld by both Federal and State law, is that ambulatory boundaries based upon a shoreline erode and accrete with coastal changes, so that where the ocean or mean low water are set as a boundary, the imperceptible daily tides will shift the relative ownership of the land. The Commonwealth of Massachusetts’ law of erosion and accretion are in accord. Thus, along the Atlantic Ocean, where the Declaration of Taking uses the mean low water line as the boundary and where the southeastern shoreline has eroded, the refuge has lost land. To the northeast, where the refuge has gained land, the accretions belong to the United States.

Wilderness Designation

On October 23, 1970, Monomoy NWR was afforded additional protection when Public Law 91-504 designated as wilderness most of the land and intertidal areas within the refuge. The wilderness area designation extends to mean low water. Wilderness designation imposes constraints on how lands and waters within the wilderness area can be used. The use of motorized equipment and mechanized transport is not generally allowed in wilderness areas. Motorized boating is allowed in Monomoy’s waters because it was an established use when the wilderness designation occurred. Section 5 of Public Law 91-504 provides that wilderness areas shall be administered in accordance with the provisions of the Wilderness Act (Public Law 88-577), and Section 4(d)(1) of that law allows that the use of motorboats, where already established, may be permitted to continue (subject to restrictions deemed desirable).

There were two tracts of land that were excluded from the wilderness areas: Inward Point and Powder Hole. These areas were excluded from the Monomoy Wilderness because they contained summer cottages and other facilities still being used or in private ownership. Except for the light station, these facilities no longer exist, and land title has since transferred to the United States for all parcels. The Powder Hole exception also included 4 acres that were owned by the Massachusetts Audubon Society at the time of wilderness designation. This private inholding contained the Monomoy Point Light Station, which was subsequently purchased by the Service and added to the refuge. The law establishing the Monomoy Wilderness identified the two exceptions as approximately 90 and 170 acres, but later Regional Director Richard Griffith more accurately measured them as being 73 acres (Inward Point) and 137 acres (Powder Hole). In 2001, Service surveyors recalculated the size of these areas to 595 acres, as the exclusion areas extend to mean low water. Although these two areas were excluded from the wilderness designation, Congress intended for the

Secretary of the Interior to manage the entire area consistent with the concept of wilderness (House of Representatives, Report No, 91-1441). Due to the dynamic nature of the landscape, the configuration and actual acreage of the Monomoy Wilderness has constantly changed over the past 40 years. Most recently, in 2013 an additional 717 acres in the Nauset/South Beach area attached to the refuge and became part of the wilderness area.

The Monomoy NWR planning team initiated a wilderness review, as required by refuge planning policy, to determine if portions of the refuge (lands and waters in fee title ownership) that were excluded from the original 1970 wilderness designation were suitable for detailed study as wilderness study areas and potentially proposed for designation as a wilderness. Appendix E summarizes the inventory phase of the wilderness review for those portions of Monomoy NWR excluded from the original 1970 wilderness designation. That draft wilderness inventory (appendix E) determined that none of the current non-wilderness portions of South Monomoy excluded from wilderness designation in 1970 yet meet the eligibility criteria for further detailed study as wilderness study areas, as defined by the Wilderness Act, during the 15-year plan period. The refuge will again undergo a wilderness review in 15 years as part of the next planning cycle, at which time wilderness study area designation and the wilderness study and recommendation phases will be reconsidered for the Inward Point and Powder Hole areas. We may also conduct a wilderness review prior to the next planning cycle, should significant new information become available, ecological, or other conditions change, or we identify a need to do so.

Wilderness Character Report

In 2012, Wilderness Fellow Taryn Sudol completed a report, “Wilderness Character Monitoring Report: Monomoy Wilderness” that addresses the five tangible and measurable qualities of wilderness character: untrammeled, natural, undeveloped, solitude or primitive and unconfined recreation, and other features. Since few existing wildernesses actually have the data that extends back to designation for the measurements created at the time of the monitoring report, this initial condition assessment will be the substitute. Baseline conditions must be set as a reference point against which change over time is measured and evaluated. Ideally, all baseline data would have been collected at the time of designation. For the Monomoy Wilderness, the baseline assessment year is FY 2012. With the baseline in place, change can be monitored over time. The discussion below is adapted from Sudol’s report (2012). This report can be accessed at the refuge’s Web site: <http://www.fws.gov/northeast/monomoy/>.

Refuge at dusk



Ravin Thomasson 2013

Untrammelled

At present, it seems that nearby developments have not trammelled the wilderness' physical processes. Current management techniques result in minimal trammeling and little effort is needed to restore the wilderness' natural systems and to ensure that the most fragile and endangered wildlife persists; if this management success endures, then even less trammeling would occur in the future.

Natural

The main risks to Monomoy's naturalness are the chances of its being overrun with non-native species or having its existing habitats shift or decline due to climate change. Uncharacteristic alterations in sea level, temperature, precipitation, or soil moisture, and frequency and magnitude of storms may cause a distorted landscape that would not have happened absent mankind's effect on global warming.

Undeveloped

Although considerable artifacts and human debris are left, they appear and disappear with the shifting sands and vegetative regrowth. Today, developments and physical structures on Monomoy are limited to management tools (e.g., nest enclosures), signage, and research equipment. Motorized vehicles, mechanical transport, and motorized equipment are precluded from visitor use, and the administrative use of such is only to be permitted during outstanding occurrences and when deemed the minimum necessary. In fact, such use is generally nonexistent due to access issues and the types of activities conducted.

Solitude or Primitive and Unconfined Recreation

Outside the wilderness boundary, commercial and recreational fishing regularly occur along with other coastal activities such as kite surfing. Boat traffic is heavy during the summer; seal tours and fishing boats circulate South Monomoy. Commercial, military, Coast Guard, media, and recreational aircraft sometimes fly low over the Monomoy Wilderness, briefly interrupting a feeling of solitude or isolation. Such solitude is also intruded upon by the view of houses and prominent water towers that sustain the mainland communities.

Other Features

The principal exception is the Monomoy Lighthouse. This 40-foot high, cherry-red tower, alongside the wood-shingled light keeper's house and brick oil shed, stands on one of two excluded portions of the wilderness of South Monomoy.

The Eastern Massachusetts NWR Complex and Staffing

Since the refuge was established, it has been administered as a satellite of the Eastern Massachusetts NWR Complex located in Sudbury, Massachusetts. We use the term refuge complex (complex) to describe two or more individual refuges, typically in the same region of a state or adjoining states, administratively combined under a single refuge manager's responsibility. Present staffing for the complex includes 16 permanent positions, 13 located at the complex headquarters in Sudbury. Monomoy NWR currently has three permanent full-time staff positions: the refuge manager and two wildlife biologists. Seasonal biological technicians, term staff positions, and summer interns vary each year depending on funding. Oversight of the refuge is provided by the project leader of the complex, and staff from the refuge complex regularly assist Monomoy NWR staff throughout the year with the full range of refuge management activities, including biological surveys and monitoring, visitor services activities, construction and maintenance, outreach, and law enforcement. Appendix G shows the staffing chart for Monomoy NWR.

Refuge Funding

Successful implementation of the CCP for each refuge relies on our ability to secure funding, personnel, infrastructure, and other resources to accomplish the actions identified. This includes staffing, maintenance, major construction

projects, and individual resource project management capability, e.g., basic operational expenses such as utilities, office supplies, field supplies, travel, and discretionary biological and visitor services funding that supports shorebird study and management; beach nesting birds' predator and competitor management; northeastern beach tiger beetle research and management, refuge brochures, signage, etc. Most of these projects have been identified as Tier 1 or Tier 2 Projects in the Refuge System's Refuge Operations Needs System database (RONS). Appendix H lists RONS projects and their recurring costs, such as salaries, following the first year, as well as a list of projects in the Service's current Maintenance Management System (MMS) database for the refuge complex. Currently, the MMS database lists \$1,195,273 in maintenance needs for Monomoy NWR. This number, however, is outdated and in need of revision.

Monomoy NWR does receive a specific budget allocation annually but, as with staffing, it is insufficient to support the refuge's operations and needs. The complex provides significant support. Funding requests and assistance to Monomoy Refuge are addressed in the same fashion as for the other refuges in the complex. Table 2.21 shows the specific allocation for Monomoy NWR and for the entire refuge complex for fiscal years 2007 to 2013.

Table 2.21. Fiscal Year Funding for Monomoy and Eastern Massachusetts NWR Complex.

Fiscal Year	2007	2008	2009	2010	2011	2012	2013
Base Funding (Operations)							
Monomoy NWR	\$274,370	\$330,706	\$346,343	\$360,685	\$366,545	\$364,713	\$354,194
Eastern Mass NWR Complex*	\$2,070,809	\$2,181,898	\$1,919,276	\$1,949,686	\$2,109,679	\$2,077,697	\$1,545,974
Project, Temporary, Construction, and Other Funds							
Monomoy NWR	\$26,200	\$76,200	\$1,686,633	\$137,538	\$93,338	\$465,493	\$92,811
Eastern Mass NWR Complex*	\$2,898,619	\$497,465	\$4,560,000	\$2,022,800	\$227,302	\$470,289	\$895,927
Total Fiscal Year Budget							
Monomoy NWR	\$300,570	\$406,906	\$2,032,976	\$498,223	\$459,883	\$830,206	\$447,005
Eastern Mass NWR Complex*	\$4,969,428	\$2,679,363	\$6,479,276	\$3,972,486	\$2,336,981	\$2,547,986	\$2,441,901

**All complex budget numbers include Monomoy NWR funds. These numbers include one-time construction projects, land acquisition funds, contributed funds, quarters income, etc.*

The allocation for fiscal year 2014 is expected to be flat or slightly less than previous years due to budget cuts. These numbers include funding of one-time construction projects, funding from the American Recovery and Reinvestment Act (ARRA) for the Monomoy Point Lighthouse and energy projects, income received from donations, quarters, and grants, as well as base funding for operations and maintenance.

Refuge Facilities, Infrastructure, and Maintenance

All refuge facilities currently in use include the refuge headquarters/visitor contact station, the dormitory/maintenance building, and a public restroom, all located on Morris Island. Periodic maintenance of existing facilities is critical to ensure safety and accessibility for refuge staff and visitors. The headquarters and dormitory were renovated in 2002, and ongoing energy efficiency improvements completed in 2010 included two 30-tube (approximately 48 sq. ft.) solar-thermal panels installed on the refuge dormitory, providing up to 10 gallons

of domestic hot water per hour and connected to a tank-type electrical water heater. The public restroom was constructed in 2004 at the refuge headquarters.

The National Weather Service (NWS), an agency within the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) had been co-located with the refuge at the Morris Island administrative complex since 1971; this joint tenancy is expected to continue at least through the plan period. The NWS has two buildings and a parking area in which they conduct their work. A memorandum of understanding guides the dual-use of the Morris Island facilities. The current refuge headquarters and visitor contact station building were actually constructed and occupied as an administrative office for the Environmental Science Services Administration, forerunner to the National Weather Service.

On South Monomoy, refuge structures currently listed on the National Register of Historic Places include a lighthouse, keeper's house, and small oil house built in the early 1800s for the Monomoy Point Light Station. These buildings are currently closed to the public, but it is our intention to open these facilities to local historical tour groups. These buildings require regular maintenance and received major repairs in 2011, but additional repairs can be expected in order to meet safety standards.

This CCP will explore the expansion of current infrastructure or establishing an alternative visitor contact station in the local community to help alleviate the overcrowding that would occur with increased staff.

Right-of-Way

The refuge has right-of-ways on Tisquantum Road, Wikis Way, and Stage Island Road to access its properties for refuge resource management, public use, and visitor access. Encroachments on the Wikis Way right-of-way will be resolved separately from this planning process.

Findings of Appropriateness and Compatibility Determinations

Chapter 1 describes these two decision processes in detail. When the refuge manager publishes a compatibility determination, it stipulates the required maximum reevaluation dates: 15 years for wildlife-dependent recreational uses and 10 years for other uses. However, the refuge manager may reevaluate the compatibility of any use at any time, in some cases sooner than its mandatory date, or even before the CCP process is complete, if new information reveals unacceptable impacts or incompatibility with refuge purposes. Refer to appendix D for an updated list of compatibility determinations and associated findings of appropriateness for refuge activities for our preferred alternative.

Partnerships

Monomoy NWR has been involved in many partnerships since its establishment in 1944. These would not have been possible without the cooperation of conservation organizations, town and county community leaders, State and Federal agencies, universities, and local elected officials. Those partners continue to be active in land conservation for the common goal of maintaining the aesthetic, cultural, economic, and ecological values of the region for future generations.

Our partnerships continue to expand to include not only groups and individuals interested in land conservation, but also those interested in habitat and species management, recreation and visitor services, and education and public outreach.

These partners include Mass Audubon, with whom we have a cooperative agreement that enables us to combine resources to facilitate monitoring, management, and habitat restoration efforts for piping plovers, least terns, American oystercatchers, and northeastern beach tiger beetles on Nauset/South Beach. For the last 3 years, we have been working with the Conserve Wildlife Foundation of New Jersey to study red knot migration and its regional

significance. The American Oystercatcher Working Group assists us with banding oystercatchers on the refuge and we participate in meetings. We have also worked well with the Town of Chatham, which, in particular, has allowed access to Nauset/South Beach and other lands for red knot research, has engaged us in shellfishing discussions, and has shared aerial photography.

Conservation Organizations:

- American Oystercatcher Working Group
- Cape Cod Stranding Network (International Fund for Animal Welfare)
- Conserve Wildlife Foundation of New Jersey
- Friends of Assabet River NWR
- Friends of Monomoy NWR
- Gulf of Maine Seabird Working Group (GOMSWG)
- Manomet Center for Conservation Sciences
- Mass Audubon
- Northeastern Beach Tiger Beetle Working Group
- Red Knot Working Group
- Seabird Ecological Assessment Network (SEANET)
- Wildcare Rehabilitation Center
- Cape Cod Museum of Natural History
- Student Conservation Association
- Americorps-Cape Cod
- Senior Americorps

Town and County Governments:

- Chatham Department of Health and Environment—Coastal Resources Program
- Chatham Public Schools
- Chatham Department of Public Works
- Chatham Department of Community Development.

Federal and State Agencies:

- Massachusetts Department of Conservation and Recreation, Division of State Parks and Recreation
- Massachusetts Division of Fisheries and Wildlife (MassWildlife)
- Massachusetts Division of Marine Fisheries (MDMF)
- National Marine Fisheries Service (NMFS)
- National Park Service, Cape Cod National Seashore
- USGS Patuxent Wildlife Research Center
- Federal Highway Administration
- National Weather Service

Universities and Other Educational Institutions and Organizations:

- Antioch University New England
- Tufts University School of Veterinary Medicine
- University of Rhode Island
- Clemson University
- University of Massachusetts
- University of Maine
- Provincetown Center for Coastal Studies
- Woods Hole Oceanographic Institute

Friends Group

A revitalized Friends of Monomoy National Wildlife Refuge organization continues to grow after a brief period of inactivity, and supports visitor services and biological activities on the refuge. They have assisted in developing and implementing interpretive programs and tours on the refuge in the past, written grant proposals, and could be invaluable in supporting those priority programs and helping respond to the requests for programs that far exceed the refuge's ability to meet them.

Volunteer Programs

Our active volunteer program involves student interns from all over the country, as well as local residents, clubs, and organizations. Every summer, the refuge hosts volunteer student interns, who are generally college-aged students or recent graduates. Interns spend time assisting with various refuge projects in return for housing and, when funding permits, a small daily living stipend. Their duties include collecting biological data, monitoring public use, leading nature walks and interpretive programs, designing educational displays, writing monitoring plans and grant proposals, greeting the public, and conducting maintenance on refuge equipment and facilities.

Special Use Permits, including Research

Special use permits are issued to individuals, organizations, and agencies requesting the use of refuge facilities or resources beyond what is available to the public; this includes conducting research projects in the refuge. In order to ensure that wildlife disturbance is minimized, special conditions and restrictions are identified for each request. On average, the refuge issues about 12 permits each year, with project periods ranging from 1 day to 1 year, depending on the scope of the request. The refuge manager issues special use permits on a case-by-case basis after determining whether the use is compatible with refuge purposes.

Refuge staff, graduate students, conservation organizations, and others have conducted numerous surveys and studies on the refuge, each covered by a special permit. A sampling of those research efforts is provided in table 2.22. Additional information on these studies can be obtained from refuge headquarters.

Table 2.22. Sample of Special Use Permits for Monomoy NWR Since 2000.

Year(s) Issued	Organization/Permittee	Purpose
2000	Virginia Polytechnic Institute and State University/Jim Fraser	Piping plover study
2000 to 2001	National Park Service, University of Rhode Island, and Massachusetts Audubon Society	Population demographics and spawning densities of the horseshoe crab
Annually	Blair Nikula	International shorebird surveys
2007	University of Massachusetts- Amherst, Entomology Department	Brown-tail moth survey
2007	Cornell University	Nitrogen disposition study
2001 to 2002	Manomet Center for Conservation Sciences	Study of organophosphate levels in night herons
2001–2012	National Marine Fisheries Service	Gray seal population and diet studies
2003 to 2005	I.C.T. Nisbet and Company Scientific Consulting	Follow-up studies to investigate effects of Buzzard's Bay oil spill on common terns nesting on Monomoy NWR
2008	Provincetown Center for Coastal Studies	Photo identification of individual gray seals and harbor seals on South Monomoy
2007	Antioch University	Roseate and common tern use of staging sites during the post-breeding period
2005	Town of Chatham	Investigation on impacts of commercial shellfishing within refuge boundary on shorebirds

Mosquito Management

The refuge lies within the jurisdiction of the Cape Cod Mosquito Control Project. The CCMCP has conducted mosquito control activities on Morris Island (both on and off-refuge) since the CCMCP was organized in 1930. Mosquito and arbovirus

surveillance, monitoring, and treatment within the refuge historically focused on several small saltwater wetland areas on Morris Island harboring *Ochlerotatus cantator* and *O. sollicitans*, “bridge vectors” for West Nile virus transmission to humans. The CCMCP controlled larval mosquitoes in these small pools from at least 1983 until August 2001, when the practice was suspended pending review of the Service’s new compatibility process. In July 2003, the Service found mosquito surveillance and limited mosquito control to be compatible, and the CCMCP resumed surveillance and larvicidal mosquito control of select mosquito species.

The refuge has worked with the CCMCP to reduce the quantity of insecticides used on refuge lands and ensure activities are consistent with the Service’s policies. Mosquito management is a complicated issue for the refuge. Monomoy NWR is adjacent to residential beach communities where nuisance issues are amplified. The control of mosquitoes is a State priority and a reality of management of salt marshes in Massachusetts, and on the refuge as well. Pesticide treatment is not be used on Monomoy NWR solely for nuisance mosquito relief, and is only considered when there is a demonstrated human or wildlife health risk. Only pesticides identified in the special use permit and for which a pesticide use proposal has been submitted and approved are used on the refuge. Two types of treatment historically employed to control refuge mosquito populations within salt marsh habitats are larvicide (*Bacillus thuringiensis* var. *israelensis* (Bti) and Aquabac) and pupacide (Agnique). No adulticides have been used in recent decades.

West Nile virus was first detected in birds, mosquitoes, and humans in Barnstable County in 2003. West Nile virus was detected in mosquito pools in 2003 to 2006 (Towns of Falmouth and Barnstable) and 2008 to 2009 (Towns of Barnstable and Bourne). West Nile virus was detected in dead birds (primarily corvids) in Barnstable County in 2005 (three positive samples, including one from Harwich) and 2006 (nine positive samples, including two each from Dennis and Brewster) before testing of dead birds was discontinued in 2009. Two human West Nile virus cases were documented in the Town of Barnstable, one case in 2003 and another in 2007. There have been no human West Nile virus cases documented for Chatham or surrounding communities (Harwich, Dennis, Brewster, or Orleans). West Nile virus has not yet been detected in humans, dead birds, or mosquito pools in Chatham.

Periodic outbreaks of eastern equine encephalitis virus, with an epicenter in southeastern Massachusetts just west of Cape Cod, are also documented. The majority of human eastern equine encephalitis virus cases have occurred in Norfolk, Bristol, and Plymouth counties, although some cases are documented for Middlesex County, Essex County, and as far west as Worcester County.

Although the historic eastern equine encephalitis virus epicenter lies just to the north and west, Cape Cod and the islands (Martha’s Vineyard and Nantucket) have no documented human eastern equine encephalitis cases or deaths. During 2012, eastern equine encephalitis virus was isolated for the first time in the mid- to lower-Cape region from mosquitos captured adjacent to Nickerson State Park in Brewster, but there are no eastern equine encephalitis virus occurrence records yet from Chatham or Harwich.

Larvicide treatments to reduce the threat of human transmission of West Nile virus were applied annually to select Morris Island wetland areas along the refuge boundary from May to October, after monitoring

Hooded merganser



Tim McCabe

Peter Paton 2013/University of Rhode Island



Tern colony

indicated *O. cantator* and *O. sollicitans* larval counts exceeded an average of 5 larvae per standard (350 ml) dipper.

Pupacides are only used when large numbers of mosquitoes are considered an immediate threat to human health and thresholds developed by the appropriate public health authority are exceeded, such as when there is active transmission of mosquito-borne disease from refuge-based mosquitoes or within flight range of vector mosquito species present on the refuge.

Adulticide treatments have not been applied on or near Monomoy NWR in recent decades, but were applied just west of Cape Cod during 2006, 2010, and 2012. In August 2006, an eastern equine encephalitis virus outbreak prompted the Governor to declare a public health emergency for Plymouth and Bristol Counties, well west of Chatham. Aerial spraying of adulticides was used for the first time in 16 years. In August 2010, the Massachusetts Commissioner of Public Health issued a certificate of public health hazard due to the high risk of eastern equine encephalitis virus transmissions to humans for this same area; this again prompted aerial spraying of the adulticide sumithrin. In 2012 the same general area was treated with adulticides due to a high risk of eastern equine encephalitis virus transmission. For additional details on the refuge's mosquito management program, refer to the Mosquito Control Compatibility Determination in appendix D.